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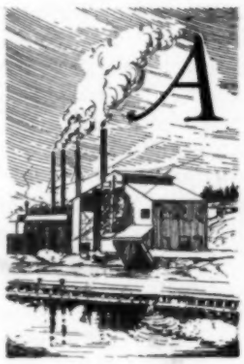
Waste—Byproduct—Staple



A WELL-KNOWN writer once said, "Waste is merely raw material in the wrong place." In proof he cited the evolution of many of the leading commodities of commerce that have sprung from the humble origin of waste products, risen to recognition as byproducts, and finally become the staples of world trade. In no industry is this changing status of materials more strikingly demonstrated than in chemical manufacture. Calcium chloride, gypsum, saltcake and niter cake, chlorine, cottonseed, coal tar, gasoline are but a few of the hundreds of chemical staples that once were wasted or were the objects of costly schemes of disposal. Unfortunately, however, many of our industries today must continue to wrestle with the problem of industrial wastes, not only to recover possible byproducts but also to prevent damage to the public through the pollution of streams and the countryside surrounding our plants.

THIS PROBLEM falls peculiarly into the province of the chemical engineer. The process industries are among the most serious offenders in the matter of stream and air pollution, in spite of the fact that chemical engineering methods and equipment are used in practically all waste-disposal processes. Major products of chemical industry, such as lime, chlorine, alum, and iron salts, are employed in water purification and waste treatment. Finally, because water is the single most important raw material in the process industries, the chemical engineer is constantly concerned with the problem of maintaining adequate water supplies of proper purity and chemical character.

IT IS only natural, therefore, that the disposal or utilization of wastes has come to be recognized as a definite part of the manufacturing process. In planning a new enterprise, it is now given the same consideration as water, labor, transportation, and the several other factors that logically determine plant location. In any business the cost of treating waste or recovering byproducts is charged, directly or indirectly, to the cost of the major product. It is this very practical consideration that makes it particularly desirable in times of depression to give thought to conservation and reclamation methods that may convert business losses into actual dividends.

IN PRESENTING in this issue a symposium on the best of American practice in waste disposal and byproduct recovery, the editors of *Chem. & Met.* express the hope that it may prove the forerunner of a greatly enhanced interest on the part of the chemical engineer. Many of the leading technical and industrial associations have already announced programs for discussing various phases of this vital subject. Next month at Chicago the Chemical Section of the National Safety Council will concern itself with the hazards to life and property that sometimes result from inadequate waste disposal. The December meeting of the American Institute of Chemical Engineers will center around a symposium on stream pollution and industrial wastes. Important committees of the American Engineering Council and such industrial organizations as the Technical Association of the Pulp and Paper Industry and the American Petroleum Institute are doing splendid work in this campaign of conservation. Shortly, the time is coming for a great concerted effort on the part of engineers in all branches of industry. Chemical engineers can and should lead the way.

Industrial Waste Chemical

Edmund Bulkley Besselievre was born in Philadelphia, Pa., April 6, 1887, and pursued a general and specialized course in municipal and sanitary engineering at the University of Pennsylvania, from which he was graduated in 1911 with a degree of B.S. Before becoming associated with the Dorr Co., Inc., in 1919 as a sanitary engineer, he served in the engineering branch of the construction division of the U. S. Army, being in charge of the design and construction of sanitary works at various government arsenals and cantonments. Mr. Besselievre now has in preparation a monograph for the Chemical Engineering Series on American practice in the treatment of industrial wastes.

NECESSITY is credited with the maternity of invention. Invention, welded to research, has produced a generation of exuberant offspring in the industrial developments of the last decade or two. Our progress is dependent for much of its success on properly regulated research and the practical and economic application of the results. But these same forces also are responsible for a concomitant problem of increasing concern to industry and the general public: viz., the adequate disposal of those industrial wastes that pollute our streams and atmosphere, denude our countrysides, and destroy much of the beauty and pleasure of life. Fortunately, what research has done to make us the industrial giant that we are today, research can do to recover for us our streams and our forests and to teach us how to preserve them for posterity.

Industrial wastes are of three distinct and definable classes: liquid, gaseous, and solid. The technology of their abatement and prevention is similar in basic regards, but has to some extent passed into different divisions of engineering and science. Individual technicians have arisen who will undertake the solution of a problem in one of these classes, but not in either of the other two. The cure-all for problems in any of the three classes is not always external—sometimes it may be found entirely within the plant and within the process. Correcting a waste problem in any of these fields may frequently open the door to unlooked-for profits.

The problem of industrial wastes is one peculiarly affecting the chemical engineer. This is true whether the wastes in question be in one of the three main classifications: liquid, solid, and gaseous. The creation of the waste usually is due to some chemical process within the plant, and it is fitting, therefore, that the solution should also be, and frequently is, a function of the chemical engineer. Solution of industrial waste problems involves much more than mere chemistry. It involves the knowledge of general engineering principles, for ways and means must be devised to collect the wastes, to retain them, and to treat them so that the ultimate discharge will be in a condition creating no nuisance to the eye or the nose. It involves a knowledge of public comfort and rights; it involves a knowledge of the common laws established by precedent over long years; it requires an understanding of human rights and privileges and a submergence of that selfish instinct of man that prompts him to let the other fellow look out for himself. The solution of waste problems requires expert technology in studying the problem so that the ultimate result may be an economic possibility for the plant owner. It must take cognizance of the inherent rights of an owner to pursue his business with the least hindrance, provided he shows a proper respect for the comfort and health of his fellow men, and provided he adopts a reasonable attitude and exhibits a desire to do the right thing.

All industrial plants are not necessarily offenders against these laws. Many plants of enormous size, which are the source of much employment to large numbers, may not be any way offensive, whereas, on the other hand, a small industry, employing only a few hands, may cause discomfort and ill-health to an entire community. All industry, therefore, must not be blacklisted without due study. Many industrial plants are offenders in discharging only one of the three classes of waste; others may multiply their troubles and problems by discharging all three.

Liquid wastes—that is, the liquid discharges from mills carrying away waste products of the plants—are perhaps the most dangerous to life in general, as they affect not only human life but the life of animals and fishes as well. It has been, and still is, the custom to discharge such wastes into the nearest watercourse without much regard to the use of the stream by others. Liquid discharges from factories and mills may contain ingredients harmful to man and beast—poisonous chemicals, colors, dyes, petroleum byproducts, oils, greases, organic matter in solution, dirt, and general filth. If this water is used for the purpose of supplying potable

Disposal as a Engineering Problem

By

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Sanitary Engineer
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water to anyone, and it is used indiscriminately without warning, much distress and harm may be caused. Epidemics of intestinal diseases of various kinds, skin diseases, infections of the eyes or other organs are but a few of the ways that humans may suffer. Animals that must depend upon the stream for their source of drinking water may be poisoned, may transmit typhoid and other diseases through the milk of cattle and goats, and may die and thus cause loss to their owner. Fish, if they can live at all in such a stream, suffer through poisoning, through choking of their gills with solids in suspension, and their usefulness as food is destroyed. Many localities in New Jersey, Maryland, and Connecticut are known where formerly oysters were raised in enormous quantities and enjoyed a wide and enviable reputation because of their excellent quality, but are now no longer harvested because of the danger of transmission of diseases through their consumption. Instances of this kind may be cited indefinitely, but it is not within the scope of this paper to describe them.

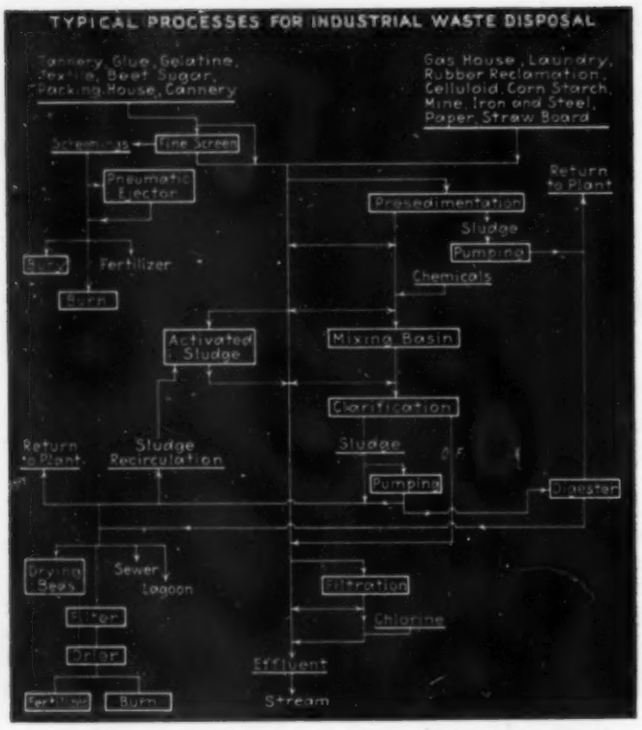
Solid wastes usually are the residue of plant processes. They may take the form of such harmless substances as bits of wood or metal scraps, which are annoying only in that if piled indiscriminately around the plant, they may make the neighborhood unsightly or become harborages for rats and other vermin. On the other hand, they may take the form of refuse, such as the pods from peas in a cannery. These pods soon become a great nuisance in the vicinity, developing the characteristic disagreeable sour smell that is evolved when vegetable matter decomposes.

Sawdust from a woodworking plant seems an innocuous type of waste, but is a menace, because of its flammability, and if it is piled close to a stream, may be washed in by storms and cause destruction of fish, due to choking of their gills. Many solid wastes may be easily disposed of by hauling away from the vicinity of the plant and incineration in public or private incinerators or by burying or use as fill. An instance of the valuable use of a solid waste product may be cited of a chemical plant on the Kearny meadows, in New Jersey, where the land surrounding the plant has been built up to a height of over 6 ft., thus bringing it above the tidal level of the adjacent marsh. Thus, by intelligent dumping of this end product and an attempt to dispose of it in a beneficial way, this company has developed a number of acres of solid ground, where before only marsh existed. From the neighboring wide expanse of marshy land surrounding the plant this industry has an almost interminable disposal ground for this waste product.

Other industries might well take a leaf from this company's book. Slag banks of steel mills might be distributed over areas in the same way. It does not seem essential to pile the material to a height of 25 or 30

One Industrial Waste Creates Another Which Must Be Removed to Prevent Stream Pollution

Flue dust is scrubbed from the blast-furnace gases at this iron and steel plant, but after the equipment was installed it was necessary to build a waste-treatment plant to remove the accumulated solids from the effluent of the wet-gas scrubber.



ft., thus making a large area of land inaccessible and useless. This same material, piled to a depth of 6 ft., or even less, and spread over a larger area, might easily return to useful purpose land which, due to marshy conditions, would otherwise be worthless. The huge piles of the wastes at some of the alkali works also are mute evidence of the futility of piling this material to great heights.

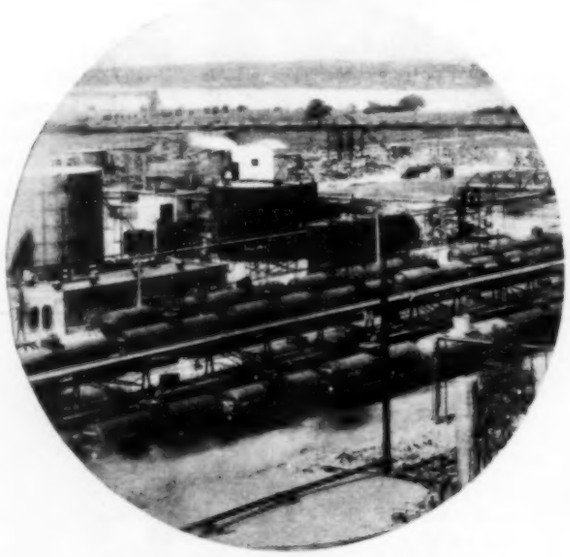
Gaseous wastes are those which usually are the result of the vapors of products used in the process, the waste gases from the combustion of the fuels, or the heated discharges from furnaces used in the fusion of materials or other thermal processes. In many instances these fumes may be colorless, but if they contain acids, may be extremely irritating to the membranes of the throat and nose. Fumes and gaseous discharges may be harmless in themselves, but may carry finely divided solids which fall to the ground and cover it with a heavy pall of dust and dirt. Embers may be discharged which are a potential source of danger of fires and consequent loss of property and life. Smoke itself, while not essentially harmful, may throw such a pall of darkness over the surrounding territory as to blot out the sun and cause the lowering of human morale that comes from living in darkened places.

The Persistent Pursuit of Profit

In its infancy, industry cared little for economy in its processes. The hugh tailings piles so common at the large mining developments are mute evidence of the waste that accrued in bygone years. The mountains of slate and unpicked coal at the mouths of the coal mines; the long, damlike hills of waste phosphate washing in Florida show how little the pioneer thought of extracting the maximum value. Prices high, ready sale, demand in excess of the supply, and in the rush to produce and ship, the last ounce of profit was not considered, and these evidences of thoughtlessness are the result. Lately all this has changed. Production overcoming demand, combined with increased competition and lowered prices, has caused many an industrialist to look around him to see how he could extract an ounce more of value for a few cents more of cost. Intensive study by many trained technicians has shown the fallacy of throwing away so much, and many of these waste piles are being reworked, with the common result of more value to the owners and a lesser amount of waste for disposal.

Increasing Concern for the Public Health

In the past few years, public health has been put on a basis of economic value. It is not profitable for a municipality to have itself known as an "unhealthy" place. This awakening of the public "health-mindedness" of our citizenry has resulted in the passage of laws and the formation of governmental agencies to protect the health of the public by regulation of the destructive elements, and when these agencies have bestowed upon them the power to enforce their demands, their remedial efforts become remarkably effective. Thus, every one of the United States, all of the provinces of Canada, and most of the foreign countries and colonies have established agencies for health. As pollution of streams and pollution of the air are causes of disease, the responsibility for abating such pollution usually falls under these health organizations. Most of them are manned by efficient medical men, and their engineering staffs, which handle the direct matters of pollution, are composed of highly trained sanitarians, who have been willing, in most cases, to accept the satisfaction of a worthy deed well done in lieu of part of the emoluments which might be theirs in civil life. Important as it is, this work of protecting the health of the state is not well paid, and many of those best qualified to carry it on to success are those who receive the least recompense. To these men must be given much of the credit for the vast amount of pollution abatement that has been effected.



A Canadian Installation of the Goodwin Process for Removing Carbon From Petroleum Distillates

It is perhaps not entirely fair to say that an industrialist will not take the means to remedy a pollution problem until he is forced to, but in many cases such an attitude is due entirely to lack of intelligent coordination of the two most involved: the public and the owner. Many times what may at first seem like an exorbitant expense in order to stop polluting a stream may prove to be a

boon to a plant by the proof to the owner that he is throwing away a product that may be of value. Mere demand upon an industrial plant to cease pollution is not sufficient. This tends merely to raise a barrier between the agency issuing such an order and the plant owner. Modern economic teachings show that by intelligent cooperation much can be accomplished with an entire maintenance of good will, that mere compulsion would breed resentment and a study of means to circumlocute the law. Gathering around the conference tables the representative of the state or other agency asking for the abatement, the owner or his agent, and the technical assistant or consultant who is to advise the owner, will eventually bring in one thing: results.

Procedure Toward Solving the Problem

The conditions in such a case are these: complaint of the pollution, stepping in of the health agent, serving of notice on the owner to meet and discuss a remedy, and the conference. The health agent states his case and calls to the attention of the owner the rights of others, and requests that he take steps to remedy the trouble. The owner or his agent, if he acknowledges the trouble, will ask the health officer to state his ideas as to the necessary degree of treatment that he must give and to outline a reasonable policy of completion; the technician will question the health officer and the owner as to needs of the stream and plant conditions and will endeavor to correlate these data into a study which will enable him, with the record of similar work at his disposal, to devise and recommend a means for treatment that will be economical and effective.

It is a matter of record, based upon the handling of many industrial waste problems over a period of years, that there is no waste discharged for which there is not a treatment. It is difficult at times, however, to show that a small plant may install such a treatment at a cost which will enable it to continue in business at that location. The extraction of the last shade of color from a spent dye liquor may be an extremely expensive process, so that to carry this out would force the plant to the wall. In such cases relocation of the plant may solve the problem, or the wastes may be partly checked by a study of plant processes and tightening up operations here and there. Sometimes the wastes may be combined with those of another plant, resulting in a product which is susceptible of easy disposal.

Many streams are not used for drinking-water purposes, and arbitrarily to demand that a manufacturer located on such a stream purify his wastes to a crystal-clear drinking-water standard is placing an unjustified burden upon him. The State of Pennsylvania, through its Water Board, has laid the groundwork for an intelligent understanding of such problems by classifying all the streams of the state into three clases: those which are to be used for drinking water and require complete treatment of wastes or no discharge at all; those which are, through old-standing pollution, not used for potable purposes, and in which discharges are permitted or a

These Industries Have Typical Waste-Disposal Problems

Paper Pulp and Paper Manufacturing

Enormous volumes of water carrying heavy charges of waste paper pulp, sulphite liquors, dirt and general pollution of a nature that makes sludge banks, kills fish, and renders water unfit for potable purposes.

Meat Packing Houses

Large volumes of waste containing blood, paunch manure, bits of flesh and hide, general floor sweepings, grease, and fat. Organic solids which decompose readily, with disagreeable odors.

Tanneries

Large volumes containing spent lime, tan liquors, dyes used in coloring leather, bits of flesh, and much hair. Wastes are brownish red in color and odorous, due to high organic solid content.

Glue Factories

Large volumes containing much lime used in vats, bits of flesh and hide, general dirt. Wastes usually a dirty, milky color, and quite odorous.

Textile Mills

Large volumes of waste containing spent dye liquors, caustic, chlorine, sulphur colors; wastes vary in color as discharge from vats is let out and range from one end of the spectrum to the other in the course of a day. Wastes not ordinarly very odorous, but are highly toxic to fish and vegetable life in stream.

Steel Mills

Large volumes of water, mainly cooling, but carrying large quantity of iron in suspension and solution from washing and pickling operations. Wastes usually white or reddish in color.

Coke Plants

Large volumes of water used in quenching, carrying acids, phenols, and other pollutants.

Oil Refineries

Large volumes of water used in various cleaning operations. Carries much oil in suspension, also tars and general wash-up dirt. Usually a blackish, oily color and not particularly odorous.

Canneries (Fruit and Vegetable)

Large quantities of water containing fruit and vegetable skins, peelings, pods, vegetable fibers, weeds, bits of skin, and juices. Color ranges from red from tomato canneries to clear water with floating solids from pea canneries. Corn cannery wastes are milky in appearance. Become very odorous if retained long without treatment.

Milk Products Plants

Creameries, condenseries, milk powder plants discharge large volumes of water containing dilute milk from spills, floor washings, discards, etc. Also large volume of caustic from floor washing compounds. Decompose very rapidly and must be treated without delay. Usually color of dirty milk.

Straw and Paste Board Mills

Large volumes of waste containing dirt and fibrous material from raw product.

Wire Mills

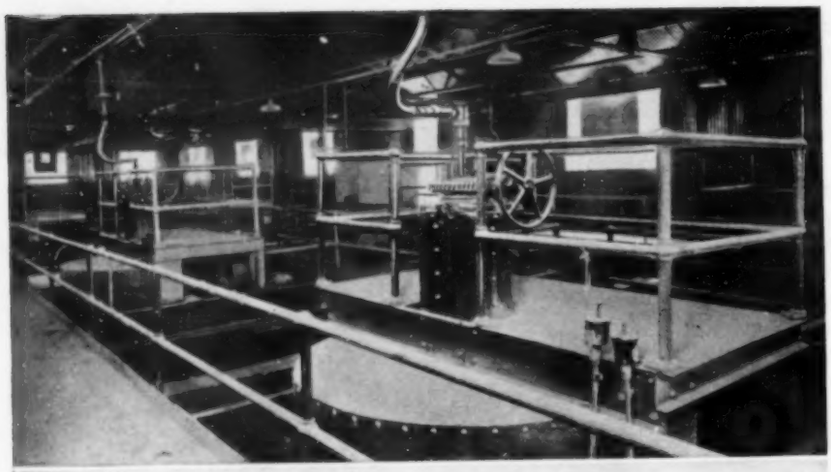
Large volumes of water used in cooling, containing acids from pickling process, iron in solution, and dirt.

Dye Manufacturing Plants

Small volumes of water containing high concentrations of color from waste in dye kettles, discards of untrue colors, etc. Usually highly colored, running a gamut of shades.

Beet Sugar Mills

Large volumes of water containing much suspended solids in form of beet tops, slicings, skins, beet juice, lime, etc.



Above—In One of the Cement Plants Where Blast Furnace Slag—Formerly a Waste Product—Is Converted Into a Valuable Raw Material

Below—Textile Wastes Are Treated in This Plant to Prevent Stream Pollution

minor degree of treatment is required; and those which are not in any way used for potable purposes, nor in household or factory use, and in which wastes may be discharged without treatment. This far-sighted policy in recognizing the rights of industry has resulted in many industrial plants being built in Pennsylvania.

In some instances the correct and economic means for treating a given waste may not be definitely known. Where this waste is common to an industry and the industry is a large one, with many establishments, cooperative experimental plants may be established to determine, at the common expense of the many, with a small contribution by each, the ways and means of treating the wastes of that industry and making this knowledge available to all. A noteworthy example of this has been the Tannery Waste Experiment Committee of Pennsylvania, composed of engineers appointed by the State Water Commission, and the body of tanners, which, through the agency of a fund contributed by a large number of firms, set up an experimental plant at the tannery of one of their number to find a reasonable solution for the complete treatment of tannery wastes, so that they might be discharged into small streams. This committee did a remarkable work and has published the results of it ("Treatment of Tannery Wastes," Department of Health, Commonwealth of Pennsylvania; Appel-Stevenson-Milligan; December, 1930). The meat packers have carried on somewhat similar work at the plants of several of their members. The paper manufacturers, through their efficient association, have studied long and hard the problem of the treatment of pulp wastes; the oil refineries have done the same; and it is becoming recognized that large industries may develop valuable data through such work, at small expense to the individual.

It is not sufficient, however, to say that because a plant is producing a product similar to another plant, using the same basic materials and the same processes and methods, the wastes from such a plant will respond to the same type of treatment as those of the other. Characteristics of water, local conditions and operating inefficiencies may make it necessary for one plant to utilize a very expensive complete treatment process, whereas the other plant may be amply protected with a treatment much less thorough. These facts, borne out by experience, call for the most careful study of each case on its own merits, and the solution of each problem separately.

There are as many classes of wastes as there are industries, but all wastes are not harmful and all do not require treatment. Many plants discharge relatively clear water, without chemical pollution, but carrying small quantities of dirt or organic matter which may be oxidized by the oxygen in the stream. Industries which are the main offenders are those that discharge large volumes of liquid wastes containing high percentages of organic solids, spent dyes or colors, acids and other chemical compounds, or through gaseous emanations pollute the air with noxious fumes and odors. It is impossible, in the scope of this introductory paper, to discuss at length all of the various types of wastes which are of a polluting nature, or to describe the methods of treatment of such wastes. Rather, it is the intention of the writer merely to point out the salient factors of waste pollution and to serve as a guide to the later papers that delve more completely into the individual problems of the several types of wastes, and discuss each in its turn.

The industries that present the greatest problems of waste disposal, and the main constituents of these wastes, are shown in the accompanying tabulation. The composite flow sheet indicates, in a general way, the usually accepted methods of disposal.

Typical Operations in Waste Disposal

What to do with any one of these given wastes is, as previously shown, a problem requiring intensive study, and it is not within the scope of this paper to undertake to describe the several means of treatment that may be adopted for each of them. It is the logical part of the chemical engineer to study the peculiar local problem of the definite case, and, with a knowledge of the demonstrated means of treatment before him, to select that one which will give the desired result at the minimum cost.

Briefly, however, it may be set down as a cardinal principle that wastes containing fibrous solids may be completely or partly treated by means of screens; wastes containing solids in suspension frequently may be handled by quiescent sedimentation with mechanical collection of

the sludge; and wastes containing solids in solution, dyes, iron, etc., respond readily to precipitation by the use of various common coagulants. Frequently, when a waste contains fibrous suspensoids and dissolved solids, it is necessary to employ a combination of all three methods of screening, sedimentation, and precipitation. Naturally, the more complex the treatment becomes, the more costly it will be.

Cost of treatment cannot be set down definitely for any one type of waste. Local conditions vary so much from one extreme to the other that, whereas a simple treatment may suffice to produce the effect at one plant, a much more complex system may be required at another plant producing a similar product. The use of the stream to which recourse is had as a point for final discharge, the volume of water in the stream, the character of the water, the character of the neighborhood immediately adjacent to the plant, the type of inhabitants near by, are very strong influences in the scope and type of treatment selected for any given case.

Costs may vary with the use of simple sedimentation alone, from a very few cents per 1,000 gal. of waste treated to as much as $2 to $5 per 1,000 gal. On a very small volume of waste—say, 5,000 to 10,000 gal. per day—a cost of a dollar or two per thousand does not loom very large, but in the case of many of the industries, which have total daily discharges of from 50,000 gal. to several millions of gallons, any cost more than a few cents per 1,000 gal. soon becomes ruinous. In general, it has been found that satisfactory results may be obtained on most wastes at a cost which may range from 5 to 20c. per 1,000 gal.

In the higher flow ranges, a careful study of the problem is thus even more warranted than ever, with the idea of developing that treatment which will respond with the least use of chemicals. Combinations of wastes to obtain the reactions between acid and alkaline wastes may frequently be employed to economic advantage, and at a great saving in materials. Usually, where chemical treatment is required, the use of such common coagulants as lime, alum, ferrous sulphate, and ferric chloride, all of which are cheap and readily procured, will result in material saving.

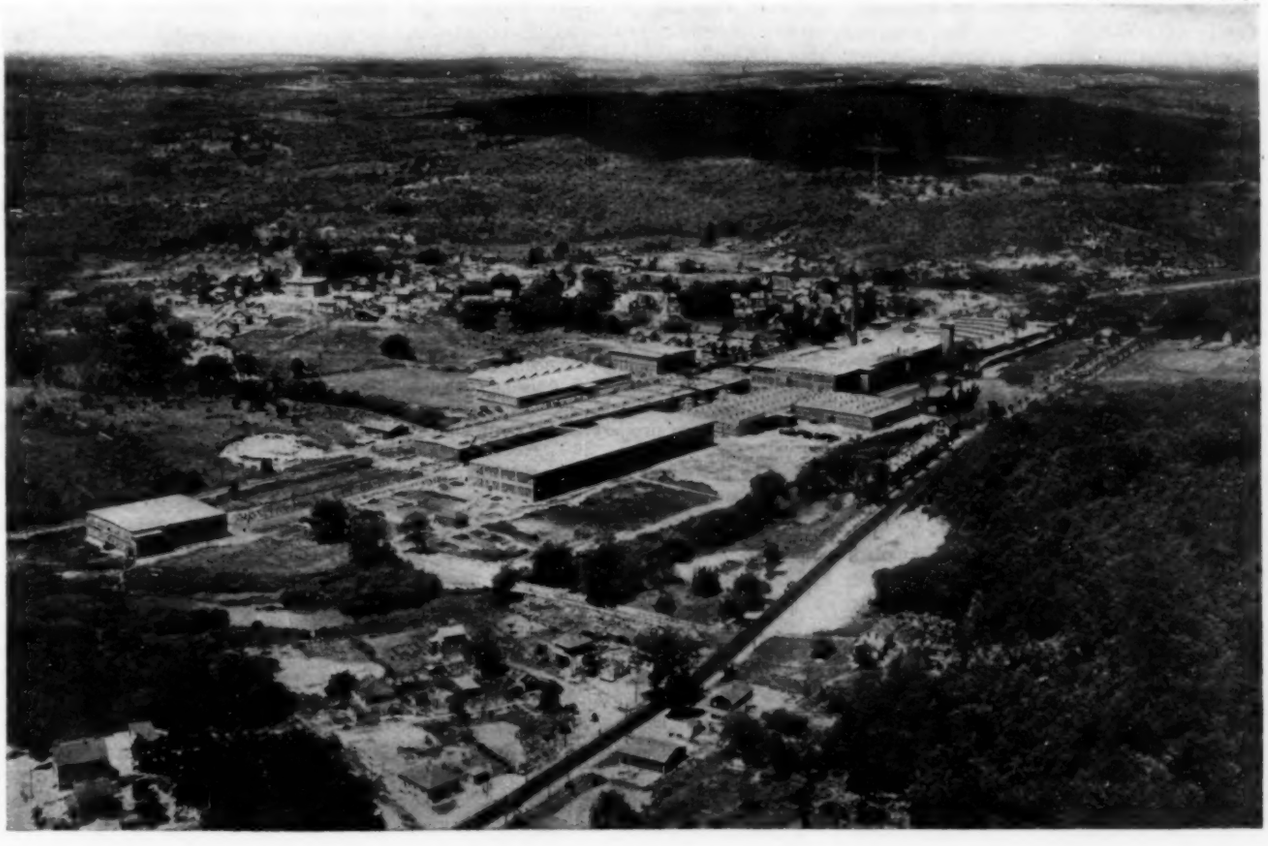
Development of the recovery of byproducts from wastes sometimes offers a slight return for the client, which tends to offset some of his expense, but it is my opinion that the premise should always be that the waste problem is to be attacked as such, seeking the most economical solution consistent with the situation, and then later to ascertain the recovery value of any byproducts.

It is a delusion and a snare to start out with the idea of recovering sufficient valuable product from a waste to make the proposition self-supporting. There are many graveyards at industrial plants of equipment and machinery that have been sold and installed on such claims, and usually, after a few years of expensive operation, have been discarded. Better to look at the thing philosophically and aim for the mark of solution of the problem; then, if there is a valuable byproduct recoverable at small expense, you can say, "There is a Santa Claus." Broad-mindedness will, in the end, result in less strain on the pocketbook than the effort to look for savings first. The cardinal and terminal principle, then, in waste treatment is: cooperation, courage, and common sense.

Waste Disposal Takes Its Place as a Small But Extremely Important Unit in a Large Textile Establishment

This aerial view of the Esmond Mills at Esmond, R. I., shows the waste treatment installation at the left of the large central building. It includes a clarifier house, sedimentation tanks, and sludge beds.

—Fairchild Aerial Photograph



Sportsman
Industrialist
Sanitarian
View

Stream Pollution

By
ABEL WOLMAN

Mr. Wolman's experience with problems of stream-pollution control dates back to 1914, when he joined the Maryland State Department of Health. Today, he is its chief engineer. In addition to his duties with that organization he has served as an editor of the American Journal of Public Health and the Journal of the Association of Water Works

IN 1807, Isaac Weld, an Englishman traveling in the United States, commented on the then temporary capital of this country, Philadelphia, in the following terms: "And behind the wharves, Water Street, narrow, shut in by the old bank of the river, dirty, filthy, stinking." At that time Philadelphia had the large population of approximately 60,000. It already had the beginnings of a distinct stream-pollution problem.

Some fifteen years before that time, Alexander Hamilton obtained from the Legislature of New Jersey one of the first industrial charters for the development of manufacturing industry at Passaic Falls, in the vicinity of Trenton. Thus, approximately over 130 years ago, Hamilton and others began the creation of a stream-pollution problem in the United States which still rises to plague the industry, the official and the sportsman.

Concomitant with these increases in population and industrial expansion, three other major developments have occurred to aggravate the problem of sewage and trade-wastes disposal. The invention of the water closet by Sir John Harrington in England, a little over a century ago, transferred the pollution problem from near by the dwellings to the nearest body of water. The demand on streams for water supply, commerce, agriculture and recreation has moved forward with terrific speed. The unpopularity of sewage-disposal costs, low as they are, has retarded the installation of correctional equipment, while in many instances the absence of technical information on the treatment or recovery of industrial wastes has played a similar retarding rôle.

Without reviewing in detail the technical features of this problem it should be apparent to the observer that there is much in this century's progress to account for the present interest on the part of virtually all individuals in the stream-pollution problem. Even at this day the bulk of domestic sewage is discharged into near-by streams with little or no treatment. The Ohio River, for example, receives the raw sewage discharges of approximately 6,000,000 people, while the Great Lakes are the receptacles for the raw discharges of another 6,000,000.

In general, the major harmful effects of pollution may be summarized as follows:

1. The contamination of portable water supplies with damage to health.
2. The development of nuisance objectionable to public health and comfort.
3. Damage to property with depreciation of values.
4. The destruction of fish and other natural stream life.
5. Damage to livestock.
6. Interference with recreational facilities.
7. Interference with commercial uses of a stream.
8. Specific toxic effects due to particular industrial wastes.

It is unimportant to analyze in any detail the ways in which domestic or industrial wastes produce the results indicated above, but there is ample technical evidence, experimental and otherwise, to demonstrate fully that the floating solids, fats and oily products, settleable solids, non-settleable putrescible materials in complete or partial solution, bacteria and specific toxic products, produce situations in receiving bodies of water, unless adequately controlled or treated, which are harmful in one or all of the fashions above presented. The specific determination of causes and effects is one of careful scientific procedure, reinforced by judgment and experience in interpretation. Although the techniques for these determinations are well known, they are not so simple in principle or in application as to make their use by the ordinary layman of any value. These facts are of importance in an effort to make clear that the control of stream pollution is not one of simplicity, to be solved by rule of thumb methods and by snap judgment. It is one of the principal reasons why it is doubtful that the problem may ever be solved by the drastic invocation of law rather than of reason.

Economical methods for the treatment of domestic sewage are available. In the hands of careful and experienced engineers a method can be easily presented to treat domestic sewage to any degree desirable. The state of the art, however, is not nearly so far advanced in the case of industrial wastes. For many of these latter, treatment or recovery methods are unknown.

The determination of when and how to treat domestic or industrial wastes is one of scientific evaluation and not one of mere recourse to enforcement of common or statute law. The simple realization of this principle has given rise to the evolution in this country of administrative agencies for the study, prevention and regulation of stream pollution. Arbitrary and complete closure of in-

dustry to solve a problem of scientific importance has failed, not only in this but in other countries. The history of stream-pollution control in England until recently has been one of almost complete failure. Prohibition of discharge was the earliest expedient. It failed. This was followed by the effort to subject the discharges to one universal form of treatment. This failed. And in recent decades England's plan has been to place the river drainage areas under the control of continuing administrative bodies, equipped with scientific personnel, whose function it is to regulate the situation in the light of a moving body of facts rather than of a stationary concept of law. The history of stream-pollution legislation in England, a country where states rights do not create additional problems as in the United States, should give the American investigator in this field much food for thought and an excellent guide for future action.

In the light of the fact that the history of stream-pollution control abroad and in this country points to the necessity of providing some flexibility in the determination of causes, effects and changes in domestic and industrial waste discharges in streams, it has become apparent during the last 25 years that administrative agencies must be created to study the conditions of stream pollution, the methods of treatment of wastes and the standards of stream cleanliness which we hope to attain. The scientific problems involved in stream pollution are not only extremely difficult in nature but of great variety.

The determination, on the part of an administrative agency, of an equitable balancing of conveniences for maintaining the stream in its natural, pristine state, preserving it in a form suitable for drinking water, the preservation of fish, agricultural use, industrial use or recreation naturally gives rise to a series of competitive demands. These may not be simultaneously reconciled to the advantage of all. There must be some give and take in the control measures. Complete elimination of industrial discharge to save a few game fish cannot be the acme of desirable administrative control. On the other hand, indiscriminate discharge of industrial waste, on the part of a belligerent industrialist, likewise does not meet the requirements of good sense. Now and then an industrial waste confronts the administrative agency whose treatment has so far not yet been developed. This is particularly true of the acid mine liquors from the bituminous coal industry. Closing mining operations in Pennsylvania and West Virginia is hardly the answer to that problem. Slow development of correctional measures, administrative and technical, is gradually taking place, but no prohibition either by law or by administrative authority is an intelligent answer to a pressing problem.

A growing recognition of the fact, however, that a river, in the words of Justice Holmes, is "not only an amenity, but is also a treasure," is bringing industrialists, sanitarians, sportsmen, and officials on some common grounds from which fruitful results for the future are certainly to be anticipated.

As in all evolutionary measures, experience and experiments are producing various forms of administrative control. Which of these forms is the best is quite an academic question. For practical purposes, it is true, in this field as in others, that varieties of methods of attack, governed by the nature of the local problems, are more likely to result in permanently important values than to attempt to standardize the methods of state or federal control universally throughout the United States. The form of control implicit in the Sanitary Water Board of Pennsylvania, paralleled by similar agencies in Illinois and Wisconsin, may prove completely satisfactory for those areas. A more central control lodged in the state departments of health as in Maryland and Massachusetts, in turn, appears to be functioning successfully with their local problems. Where interstate situations occur, voluntary efforts, coupled with educational procedure, are bringing surprisingly good results in this country. The operations of the Ohio River Board of Public Health Engineers, followed later by a similar group on the Great Lakes, have produced improvements in pollution control in the last few years which were hardly to be anticipated fifteen years ago. Without legal status and without the club of law, these voluntary interstate groups may be the real answer to river-drainage area problems in this country. Their primary deficiency is in the absence of industrial participation in both discussion and voting power in the establishment of principles and methods of control.

Knowledge is a great leavener of contesting opinions. Ever since the days of Izaak Walton the fisherman has deplored the gradual destruction of game and other fish by the pressure of civilization and its byproducts. For years the disappearing salmon on the Thames has aroused the comment of the sportsman. In the United States, the last ten years has seen a remarkable growth of organizations militantly interested in the cleaning up of streams for the future protection of fish and game. Their methods have not always been impartial or informed, but their motives have been good. In recent years these friends of clean streams have learned much of the technical complexity of stream purification and of the economic balancing of stream uses. They are becoming more and more the allies of administrative bodies burdened with the task of stream control. They have still to learn and decide whether destruction of small numbers of game fish should be avoided by the expenditure of thousands of dollars for the treatment of industrial wastes.

It must be confessed, on the other hand, that the attitude of plant owners in past years has had much to do with the development of militancy on the part of voluntary groups of sportsmen. Owing to either inertia, ignorance or excessive cost, the manufacturer has too frequently assumed prior and sacred rights to pollute neighboring streams, and, in our own experience, inertia and ignorance have accounted for more lapses and offenses than has excessive cost of treatment or recovery. The plant manager who knows what "cannot" be done with industrial wastes is perhaps the greatest retardant to stream improvement in this country. More often than is imagined, industrial waste recovery is delayed until a plant manager is replaced by one who does not know what cannot be done. The heavy hand of historical precedent should be lifted by industry from its control of the stream-pollution problem. Welcome signs of this lifting are available in many instances in the last ten years. The promise is excellent for the near future. Industry is accepting the gauntlet thrown down by sportsman and administrative official, we believe, to general advantage.

If one may risk the danger of prophecy, the present writer would predict that the future will show an increasing emphasis on scientific research in the field of industrial waste treatment. Balancing of conveniences and coordination of uses of streams will be the controlling guide. Recovery, rather than treatment of wastes, will be the aim, and administrative flexibility in viewpoint and in execution, rather than rigidity of enforcement of the law, will be the incentive to the gradual elimination or alleviation of the stream pollution or alleviation of the stream-pollu- be rapid, but it will be permanent, for persuasion and conviction are not spectacular. They are fruitful in the long run. With this progress there will undoubtedly come an increased appreciation on the part of industrialists that the recovery or the treatment of wastes is an integral part of the cost of production of a commodity. Indiscriminate discharge into the nearest water course is a thing of the past. It is not only harmful, but it is wasteful.

State Laws Governing Pollution By Industrial Waste

EDITORIAL STAFF SURVEY

ALMOST all states in the Union have laws prohibiting the dumping of deleterious waste materials from industrial plants into the streams within their boundaries. Such statues are of importance to managements seeking locations for new plants, because they concern not only the disposition of wastes but, in addition, a supply of fresh water for processing and other purposes vital to many chemical engineering industries.

These acts of restriction are either incorporated in the general laws of the state or are the regulations passed by the board of health or other state organizations empowered to control stream pollution. In the case of Alabama and several other states the authority to enforce correction of unsanitary conditions goes back to the common laws in existence since the formation of the states. They were intended primarily to protect health, to assure a supply of clean drinking water, and to prevent nuisances. However, as manufacturing increased in volume in certain states, the problem of the disposition of wastes likewise increased. As a result it became necessary to pass new laws and to make new regulaions aimed directly at industrial wastes.

In certain cases laws have been made to legislate against specific wastes, such as petroleum, sawdust and other wood wastes, acids, alkalis, and white water from pulp mills. On the other hand, it has been advisable in some instances to exempt certain streams and industries from the prohibition. Delaware and Maine permit the disposal of wastes in certain of the streams that flow through those states. New Hampshire allows discharge of sewage into streams polluted prior to 1913. South Dakota, Washington, and New Hampshire exempt certain industries. The last permits woodworking wastes by mills which have been in operation prior to 1901.

In nearly every case the law includes a penalty for violation. These penalties range from a nominal amount to a large sum of money and imprisonment for the offender. However, it has been rarely necessary to penalize a manufacturer. Legal action is inaugurated only when there appears to be no disposition to effect remedies.

General practice follows a policy of cooperation with industry rather than the enforcement of severe requirements, which may often impose an unnecessary hardship on industries because the degree of treatment or modification required varies greatly with local conditions. This cooperation of the state organization having jurisdiction over stream-pollution control with the industrialists almost always results in satisfactory solution of the problem. Thirty states cooperate by inviting representatives of the offenders to a conference. Schemes and p'ans for the treatment of industrial wastes are discussed, all available information on research work upon similar problems undertaken in other states is supplied, and suggestions are made for remedying the condition.

Ten of these states extend their cooperation beyond the conference room to include engineering research work both in the field and in the government laboratories, with the object of developing methods to efficiently prevent nuisances and objectionable stream pollution. Pennsylvania, Wisconsin, Ohio, and several other states have accomplished very satisfactory results by calling conferences of various groups of industries and insisting upon the organization of each group into appropriate committees to carry on investigational work looking toward the development of methods for disposing of the wastes common to them all. The boards of health of Florida and Connecticut have gone a step farther and prescribed the methods to be used in disposing of wastes by manufacturers.

It is not the intention to cover in detail the many problems and phases of stream pollution from industrial wastes, but to present in the accompanying table a résumé of the legislation, restrictive or regulatory, promulgated by the various states. For the convenience of the chemical engineer interested in obtaining more complete information, the years in which the present law and the most recent amendment took effect are listed. Likewise the names of the state organizations which have jurisdiction over the control of stream pollution are given.

# of Streams

States	THE LAW								Cooperates With Industry in Solving Problem	Jurisdiction Over Pollution Control
	Covers Industrial Wastes	Took Effect in	Most Recent Amendment Took Effect in	Modification Contemplated in	Exempts Certain Streams	Names Certain Industries	Provides Penalty for Violation	Requires Approval of Disposal Plans		
Alabama	×	[1]	1923	....	....	....	×	....	....	Board of Health, Dept. of Conservation.
Arizona	×	1913	1928	....	....	×	×	....	....	.....
Arkansas	×	1913	....	....	....	....	×	....	×	Board of Health.
California	×	1872	1927	....	....	×	×	....	×	Dept. of Natural Resources.
Colorado	×	1921	....	....	....	×	×	×	....	Board of Health.
Connecticut	×	1925	1931	....	....	....	×	....	×[8]	Board of Health, Water Commission.
Delaware	×	1893	....	....	×	×	×	....	....	Board of Health.
Dist. of Col	×	1896	....	....	....	....	....	×	×	Health Dept.
Florida	×	1927	....	....	....	....	×	×[2]	×[8]	Board of Health, Fresh Water Fish Com.
Georgia	....	....	....	....	....	....	....	×	×[8]	.....
Idaho	....	....	....	....	....	....	....	....	....	.....
Illinois	×	1929	....	....	×	....	×	×	×[8]	Sanitary Water Board.
Indiana	×	1930	....	....	....	×	×	....	×	Board of Health, Dept. of Conservation.
Iowa	×	1924	1925	1933	×	....	×	×	×	Dept. of Health.
Kansas	×	1907	1927	....	....	....	×	×	×	Board of Health.
Kentucky	×	1928	....	....	....	×	×	×	×	Board of Health.
Louisiana	×	1910	1924	....	....	×	×	....	×	Board of Health, Dept. of Conservation.
Maine	×	1931	....	....	×	....	×	×	×	Dept. of Health, Public Utilities Commission.
Maryland	×	1914	1924	....	....	....	×	×	×[8]	Board of Health, Conservation Dept.
Massachusetts	×	1930	....	....	....	×	×	×	×[8]	Dept. of Public Health, Dept. of Public Safety, Dept. of Conservation.
Michigan	×	1915	1929	....	×	×	....	×	×[8]	Stream Control Commission.
Minnesota	×	1923	1927	1933	....	....	×	....	×[8]	Board of Health.
Mississippi	×[4]	....	....	1932	....	....	....	....	×[8]	Board of Health.
Missouri	×[6]	1928	....	....	....	....	....	....	....	Board of Health, Game and Fish Dept.
Montana	×	1907	1927	....	....	....	×	....	×	Board of Health, Game & Fish Comm.
Nebraska	×	1925	1928	....	....	....	×	×	....	Bureau of Health.
Nevada	....	....	....	....	....	....	....	....	....	.....
New Hampshire	×	1913	1926	....	×	×	×	....	....	Board of Health.
New Jersey	×	1899	1930	....	....	×	....	×	×[8]	Passaic Valley Sewage Comm., Dept. of Health.
New Mexico	×	1919	[1920	....	....	....	×	×	....	Bur. of Public Health, Game and Fish Dept.
New York	×	1903	1928	....	....	....	×	×	×[8]	Dept. of Health, Conservation Dept
North Carolina	×	1908	1919	....	....	....	×	....	×[8]	Stream Sanitation Committee.
North Dakota	×	1913	1927	....	....	....	....	....	×	Dept. of Health.
Ohio	×	1893	1931	1933	....	....	×	×	×	Dept. of Health.
Oklahoma	×	1918	....	....	....	....	×	....	×[8]	Board of Health.
Oregon	×	1919	....	....	....	....	×	....	....	Board of Health, Fish Com., Game Com.
Pennsylvania	×	1915	1923	1933	....	....	×	....	....	Sanitary Water Board.
Rhode Island	×	1910	1923	....	....	....	×	×	×	Bd. of Purification of Waters.
South Carolina	×	1926	....	....	....	×	×	×	×	Board of Health.
South Dakota	×[5]	1903	1922	....	....	....	×	×	×	Dept. of Health.
Tennessee	×	1903	1923	....	....	×	....	....	×[8]	Dept. of Agriculture, Dept. of Public Health.
Texas	×	1913	1931	....	....	×	×	....	×[8]	Dept. of Health, Game and Fish Comm.
Utah	×	1917	....	....	....	....	....	....	×	Board of Health.
Vermont	×	1890	1912	....	....	....	×	....	....	Dept. of Public Health.
Virginia	....	....	....	....	....	....	....	....	×[7 8]	.....
Washington	×	1915	1927	....	....	×	....	....	×[8]	.....
West Virginia	×	1929	....	....	....	....	....	....	×[8]	Water Commission.
Wisconsin	×	1927	1931	....	....	×	×	×	×[8]	Board of Health.
Wyoming	×	1895	....	....	....	....	×	....	×	Board of Health.

[1] Common laws have existed since formation of state.
[2] Under certain conditions.
[3] Bd. of Health.
[4] No general law relative to stream pollution other than authority invested in State Bd. of Health to regulate conditions.
[5] Said to be unconstitutional and not enforced.
[6] Laws have not proved possible to enforce.
[7] Sponsored by Commission of Game and Inland Fisheries.
[8] Includes laboratory assistance.

Attacking the Problem of Atmospheric Pollution

By
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TO BREATHE pure wholesome air is the natural right of every citizen. It is prerequisite to enjoyment of health, the comfortable use of property and pursuit of happiness. Yet in spite of those important facts, progress in preventing pollution of our breathing atmosphere by noxious gases, vapors, dusts and noisome odors has been conspicuously tardy. In fact, air pollution is still in a comparatively primitive stage of development, as evidenced by the annual increase of fatalities due to the inhalation of noxious gases, vapors, dusts, and also by the filthiness of urban air.

In everyday life our breathing air is not vitiated to an extent which causes serious injury to health except under special conditions of employment. Nevertheless urban air contains from 5 to 50 thousand or more microscopic dust particles per cubic centimeter, as well as injurious gases which are responsible for enormous damage to property, although their physiological action on human beings is not so apparent or pronounced. Such extensive contamination as obtains in the air we breathe would not be tolerated in what is ordinarily recognized as our food supply. But air is not an article of commerce and consequently little attention is paid to its purity.

Control of air pollution is a very broad subject and our attention must be confined to a humanistic phase of the subject, namely, "nuisance," the control of which is designed to promote health, safety, morals and the general welfare of the community.

The term "nuisance," which is defined in Ruling Case Law 20, 380-385, is derived from the French word "nuire" which means to injure, hurt or harm. And in a broad sense it is true that a nuisance is anything that works a hurt, harm or prejudice on an individual or the public. Court decisions have held that the term "nuisance" extends to everything that endangers life or health, gives offense to the senses, violates the laws of decency, or obstructs the reasonable or comfortable use of property. Nuisances are generally known as private and public. They are private when the injury resulting from them violates only private rights and produces damage to a few persons only, or even to one person only. They are public when they violate public rights and produce a common injury, when they injure or annoy that portion of the public which necessarily comes in contact with them.

Legal Liability for Nuisance

A landowner's right, the U. S. Supreme Court has held (Canfield vs. U. S., 167, U. S., 518-22), "will not justify him in maintaining a nuisance or in carrying on a business or trade that is offensive to his neighbors. Ever since Aldred's case (—9 Coke, 57) it has been settled law both in the United States and in England that a man has no right to maintain a structure on his own land which by reason of disgusting smells, loud or unusual noises, thick smoke, noxious vapors, the jarring of machinery, or the unwarrantable collection of flies, renders the occupancy of adjoining property dangerous, intolerable, or even uncomfortable to its tenants. No person maintaining such a nuisance can shelter himself behind the sanctity of private property."

The first regulation pertaining to pollution of the air by noxious gases and dusts probably dates from the year 1273 at which time sea-coal was prohibited by royal proclamation from being used in London as being prejudicial to human health. The common law of nuisance dates from the decision of Aldred's case in 1609, at which time William Aldred brought action against Thomas Benton for building a swine sty next to his hall and parlor. It was established that the plaintiff should recover.

Noxious Gases and Vapors

As evidenced by court decisions and nuisance statutes, the word "noxious" is used in describing the injurious properties of gases, vapors, and dusts. Synonyms for noxious are hurtful, harmful, baneful, injurious, unwholesome, noisome, pernicious, insalubrious, pestiferous. Noxious is something which inflicts evil directly. Some of the gases and vapors produced in chemical manufacture which are frequently classed as noxious are as follows: Chlorine, fluorine, bromine, hydrogen chloride, hydrogen cyanide, hydrogen fluoride, sulphur dioxide, sulphur trioxide, nitrogen dioxide, ammonia, hydrogen sulphide, carbon monoxide, cyanogen, silicon tetrachloride, silicon tetrafluoride, boron trifluoride, nitrous oxide, cacodyl oxide, nickel carbonyl, and phosgene.

Some of the sources of noxious vapors may be enumerated as follows: Aliphatic and aromatic hydrocarbons, aliphatic and aromatic alcohols, aliphatic and aromatic aldehydes, ketones, ethers, esters, halogen derivatives of aliphatic and aromatic hydrocarbons, aliphatic nitrates and nitrites, nitro compounds, amines, cyanogen compounds, aromatic nitro and amido compounds.

The defining of a noxious gas, vapor, or dust within the meaning of the term "nuisance" is necessarily based on chemical and physiological data. The difficulties involved in defining the term "noxious" may be illustrated by considering the properties of hydrogen sulphide. This gas can be detected by the sense of smell at concentrations of a tenth of a part per million in air, and such low concentrations as even one to two parts per million are not noxious physiologically to human beings although inhaled year after year during employment. Yet those low concentrations will blacken white lead paint on a house over night, providing there is a very light rain which is just enough to wet the paint, and a gentle breeze to impinge the hydrogen sulphide against the side of the house. Under those conditions, hydrogen sulphide is noxious to white paint. Yet when the air is dry and the paint dry, the hydrogen sulphide has no action and therefore is not noxious.

Although low concentrations, as cited above, are not noxious physiologically

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Dr. MacLaurin founded, and for nine years headed, the department of chemistry of the University of Saskatchewan. Five years more he devoted to solving waste treatment problems for the Canadian packing industry. In 1924 he was called to Cleveland for similar work, where later, under City Manager Hopkins, he became Commissioner of Trade Waste. He has published many articles on trade waste and on stream and air pollution, some of which appeared in recent issues of *Chem. & Met.*

in the sense of causing bodily injury, yet such concentrations have a noisome smell which constitutes an offense to the senses, and as a result are noxious. The word "noxious" therefore has many degrees of noxiousness. Apparently, therefore, hydrogen sulphide is noxious to one thing or another at concentrations of one part per million or even less.

Of course, high concentrations of hydrogen sulphide in air are noxious physiologically. A man inhaling 3,000 parts per million would probably drop dead instantly due to paralysis of the respiratory center. Owing to different susceptibilities to the physiological action of hydrogen sulphide, there can be no sharp line of demarcation between a noxious and an innocuous concentration of hydrogen sulphide in air. Certain investigators state (Bureau of Mines, Ser. No. 2491): "The exact low limit of hydrogen sulphide concentration at which it ceases to act as a poison has not as yet been determined, but is evidently below 0.005 per cent, or 50 p.p.m." Another investigator states (*Jour. Ind. Hyg., 7,* 118): "There appears to be little question that the repeated and prolonged inhalation of hydrogen sulphide in concentrations as low as 100 p.p.m. (0.01 per cent) may cause local irritation and depression of the nervous system."

These citations indicate the indefiniteness of information available on this subject, for it is an extremely difficult one, well appreciated by the writer. After many years' experience in industry where hydrogen sulphide is in the air continuously during employment, I am still unable to say definitely where the danger-line can be drawn. However, I do know that 2 p.p.m. of hydrogen sulphide in air is physiologically harmless and also that 50 p.p.m. is much too high a concentration in which to work. Therefore, in order to attempt to define the term "noxious" as applied to hydrogen sulphide, one must know its concentration in air, the humidity of the air and the subject or instrumentality to which it is related. Lastly, one's "nose knows."

Noisome Exhalations

Nuisance may be caused by noisome exhalations. Noisome means offensive to the sense of smell or other senses. The word "noisome" in the early nuisance cases was applied to exhalations emanating from swine-sties, livery stables, slaughter-houses, rendering plants, fertilizer works, glue works, and garbage reduction works. There are also other gases and vapors which may be regarded as noisome: hydrogen sulphide, carbon bisulphide, fumes from japanning ovens, fumes from the depolymerization of gums, aniline vapors and pyridine vapors.

The law is well established that legislation for promoting the health, safety, morals and general welfare of the community is a proper exercise of police power and as a consequence certain acts have been branded as public nuisances by statute or ordinance. Thus, animal enclosures, slaughter-houses and rendering plants for many years have been branded as public nuisances by common law and by statute. Yet the odors emanating from a hog are not noxious in the sense of being injurious, but merely offensive. Today a modern rendering plant can be conducted without creating even noisome odors, yet this trade is still branded by statute as a public nuisance. A modern rendering plant in no way endangers public health, in fact it is one of the least dangerous of all trades. Nevertheless, it would probably be a difficult matter to secure the repeal of such statutes in spite of the multitude of cases where noxious gases, vapors and dusts are emitted into the breathing atmosphere by industries that are not branded by statute as public nuisances.

However, in accordance with the standards of the common law of nuisance, noxious gases, vapors and dusts have been partially dealt with under compensation laws which will be discussed later. So the problem of safeguarding public health and public safety is becoming more complex owing to the increasing number of chemicals manufactured and the many new uses of chemicals in every-day life. The responsibility of the chemical engineer does not cease when chemicals are manufactured: he must follow through so as to insure the safe disposition and use of all noxious substances by the general public.

"When a nuisance complaint becomes public, as a rule it results in embarrassment to the industry in one way or another. The moral for chemical engineers is: If the neighbors complain, they are always right! Get busy and alleviate the complaint before it becomes public."

In many cases the question whether a nuisance has been created depends upon the degree of injury. The harm may be great or slight, and the determination of the rights of the complaining party and the remedy must necessarily depend on the varying circumstances of the case. It is well settled that the injury must not be fanciful or imaginary or such as to result in a trifling annoyance, inconvenience or discomfort which may affect those who have too sensitive a nature or too fastidious a taste. The law applies only to normal man—the man of ordinary habits and ordinary sense—it does not take cognizance of insensible and unsubstantial discomforts or inconveniences.

Where a public nuisance obtains, contiguous property is injured as is evidenced by property values being adversely affected. Such a result may be produced by noisome odors which in no way cause physical damage to property. On the other hand, physical damage to property may be caused by gases such as sulphur dioxide, sulphur trioxide, hydrogen chloride, hydrogen fluoride, hydrogen sulphide, bromine, chlorine, nitrous fumes, and dusts. One illustration of property damage may be cited. As hydrofluoric acid etches glass and such fumes emanate from the manufacture of frit used in making vitreous enamel, window glass in houses neighboring such works are frequently etched. The stack gases contain silicon tetrafluoride and boron trifluoride, which in the presence of air are hydrolyzed liberating hydrofluoric acid. The nuisance caused by the etching of glass by fluorides can be completely abated by atomizing hydrated lime into the stack gases. This combines with the gaseous fluorides, forming solids which may be collected in bag filters.

Incidently, it is interesting to note in this connection that silicon tetrafluoride fumes may also be prejudicial to health. In the 67th annual report of the Chief Inspector of the Alkali etc. Works Act in England, it is suggested that the Meuse Valley deaths in December, 1930, may very possibly have been caused by silicon tetrafluoride fumes evolved in the roasting of zinc blend.

The annual damage to property in urban centers caused by atmospheric pollution is probably greater than the capital cost necessary to abate 90 per cent of the nuisance; and further, the cost of obtaining comparatively clean air would be small compared to the cost of either water purification or sewage disposal.

Noxious Dusts

Noxious dusts may be classified as: (1) Those injurious because of poisonous action, such as compounds of lead, mercury, arsenic, phosphorous, barium, cadmium, zinc and thorium; (2) those which cause irritation of the respiratory tract, resulting in bronchitis and asthma, such as a majority of inorganic dusts, dusts in the textile industries, cereal dust, hair and jute dust (there are a hundred or more specific dusts which cause hay-fever and asthma); and (3) those dusts which tend to produce pulmonary fibrosis and so may predispose to tuberculous infection, such as silicious dusts, vegetable fiber dusts, and textile dusts. In general, atmospheric pollution due to dusts may be prevented by collecting them at their source by centrifugal collection, bag filtration or electrical precipitation.

Determining nuisance caused by noxious dusts is in many instances a very difficult matter, owing to the difficulty of determining which concentration of dust particles suspended in air would

constitute a noxious condition. A case in point which has been experienced by the writer involves air pollution by castor-pumice dust which causes hay-fever or asthma. In spite of the fact that the company had installed the best practicable means known to the art of dust collecting, and although it was impossible to detect castor-pumice dust in the air in the surrounding neighborhood, yet the court issued a permanent injunction against the factory's operation. Irrespective of the merits of the case, the following observation is pertinent. In this case, the installation of dust-collecting equipment was delayed until after the complaint became public. When a nuisance complaint becomes public, as a rule it results in embarrassment to the industry in one way or another. The moral for the chemical engineer is: if the neighbors complain about nuisance they are always right! Get busy and alleviate the complaint before it becomes public.

Compensation Laws

Atmospheric pollution caused by a limited number of noxious gases, vapors and dusts, in so far as they cause occupational diseases, has been dealt with by compensation laws. Although such laws have rendered a valuable service to employers and employees alike, there is still much room for improvement in the administration of the law, as is evident from the fact that only a few states have made any serious effort to prevent injury caused by atmospheric pollution. It is further evident from the fact that fatalities due to the inhalation of noxious gases, vapors and dusts are annually increasing. Occupational diseases are compensable in only 11 states, either under the blanket or Massachusetts plan, or by the schedule plan which makes compensable only certain specified, enumerated diseases. For this reason the application of the law is restricted. However, these laws have been amended from time to time by additional compensable injuries, and if the law were operative from the standpoint of prevention of injury caused by noxious substances, in a manner similar to the principle already recognized and applied to accidents, then progress in prevention would be more rapid. More prevention means less compensation.

In order to prevent injury it is essential to know the concentration in air of noxious substances during their manufacture. It is also necessary to know the concentrations encountered in trades where such chemicals are used, and further the conditions under which chemicals are used by the public generally. In cases where the concentration of noxious gases or dusts in air cannot be predetermined or known as, for example, at fires where noxious gases may be encountered in dangerous quantities as a result of decomposition or volatilization of chemicals in storage, or from the destructive distillation of certain building materials, those who are exposed must be equipped with suitable masks to prevent injury. Further, the masks should be rigidly and continuously inspected to insure the efficiency of the absorbent materials or other active neutralizing reagents. So prevention of injury due to noxious substances—i.e., the control of nuisance—is essentially a problem for the chemical engineer. He must employ the best practicable means known to the art for controlling any particular noxious substance, and in cases where means are not known he must devise new methods.

Under the administration of compensation laws in cases involving noxious substances, there has been a tendency merely to remove the offending substances from the environment of the worker by means of exhaust systems, thus discharging the substances into the outside atmosphere. This method, however, is inadequate, and as a rule when nuisance can be abated at its point of origin, the problem of air pollution is solved not only for the worker but also for the neighbors residing in the district.

Although noxious substances can be safely manufactured under intelligent technical supervision, yet in merchandising noxious chemicals it is imperative to bear in mind the matter of public safety, public health and the general welfare of the community. Be it also remembered that at the present time the public is not protected by statutory legislation against injury caused by noxious gases, vapors and dusts, and some chemicals are still inadequately labeled.

Zoning Laws

Nuisance has further been dealt with under the police power of the state in the matter of zoning. A large number of state legislatures have enacted a standard zoning-enabling act, which, for the purpose of promoting health, safety, morals or the general welfare of the community, empowers legislative bodies of cities and incorporated villages to regulate and restrict the height, number of stories, size, location and use (etc.) of buildings and other structures for all purposes. The theory of zoning as applied to nuisance has been stated succinctly by Mr. Justice Sullivan in the case Euclid vs. Ambler Realty Co. (272 U. S. 388) wherein he stated: "A nuisance may be merely a right thing in the wrong place—like a pig in the parlor instead of the barnyard." Such a conception is inapplicable to air pollution caused by noxious gases, vapors and dusts owing to the fact that it is impossible to confine them to one's premises. When noxious gases, vapors and dusts are carried by the wind to adjoining properties, the only standard that can be applied is that set forth in the common law of nuisance.

Validity of zoning as applied to aerial nuisance has not been determined by the courts. However, it is unreasonable to assume that people who reside adjacent to an industrial district do so at their own risk, a circumstance contemplated under the zoning law. Further, if an industry is a nuisance only when in the wrong place, in accordance with the theory of zoning, what redress would a manufacturer have when conducting a business in a district unrestricted under the zoning law, should his property, health and comfort be injured by noxious exhalations from a factory of another manufacturer located in the same unrestricted, zoned district? The answer is obvious. Zoning cannot make an unlawful act lawful and, therefore, as far as the prevention of atmospheric pollution by zoning is concerned, the benefits to health, safety, morals and the general welfare are practically negligible.

Smoke Ordinances

Another article in this issue discusses the present situation in smoke abatement and points out future requirements. I wish further to express my belief that the type of "black smoke" ordinance now in vogue has been responsible for seriously retarding progress in preventing atmospheric pollution from the burning of bituminous coal. "Smoke," as far as the public is concerned, means black smoke, and elimination of the blackness by greater combustion efficiency by no means abates the nuisance. Such legislation cannot prevent atmospheric pollution. In my opinion the only valid smoke legislation in this country was enacted by Congress in 1899. It provides that "the emission of dense or thick black or gray smoke or cinders from any smoke stack or chimney used in connection with any stationary engine, steam-boiler or furnace of any description within the District of Columbia shall be deemed and is hereby declared to be a public nuisance."

This act is obviously valid nuisance legislation. It was designed to prevent atmospheric pollution, whereas the "black smoke" ordinances seem to me to be of doubtful validity on the ground that their principal accomplishment is to increase the efficiency of combustion, a factor over which the police power has no jurisdiction except where at the same time a nuisance is abated.

In conclusion, therefore, most existing regulations purporting to prevent or control atmospheric pollution, such as black smoke ordinances and zoning laws, appear to be to all intents and purposes futile. The breathing air of the worker is partially protected against noxious substances by compensation laws which are being continuously made more inclusive. The transportation of noxious substances is well regulated by the Interstate Commerce Commission. The public interest is partially protected by statutory legislation in connection with fire prevention; but in the final analysis the standards established by the common law of nuisance are relied upon to protect the health, safety and comfort of individuals and of the public.

What Is Ahead in Smoke Abatement?

By

H. B. MELLER

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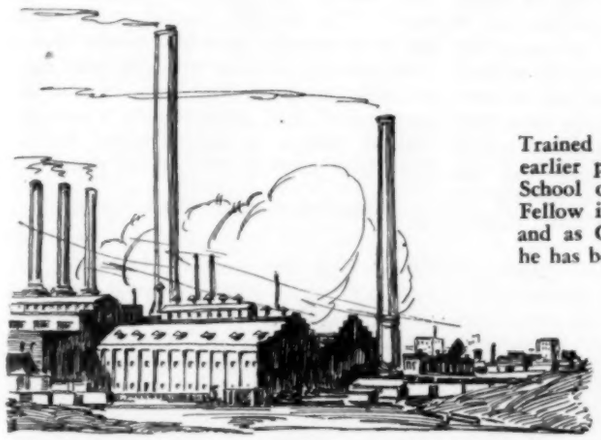

Trained in mining and metallurgical engineering, Mr. Meller spent his earlier professional years on the faculty of, and later as dean of the School of Mines, University of Pittsburgh. More recently as Senior Fellow in charge of the air pollution investigation at Mellon Institute, and as Chief of the Bureau of Smoke Regulation, City of Pittsburgh, he has become one of our leading authorities on smoke abatement

IN ITS ATTITUDE toward smoke abatement, the public may be divided into three classes. First there are those who do not realize that smoke, a product of incomplete combustion, is an indication of waste—not so much on account of unburned carbon that goes out the stack as in the unnecessary loss of heat from fuel paid for. Such persons are wont to say, "Smoke is a sign of prosperity: let us have more of it." Then there are people who are willing to go part way and attempt to obey a very lenient anti-smoke ordinance now in effect. They have profited in a material way by regulation, and cooperate to the extent of using such equipment and methods as will meet local legal requirements. Finally, there are those who want to go farther and to have controlled the emission of all solids from stacks.

Because visible smoke—an annoying part of atmospheric pollution—was so obvious, it was not difficult, when communities became "smoke conscious," to secure the enactment of legislation aimed at its control. A large percentage of the public was in the first, and practically all the rest in the second of the three classes mentioned above. Equipment and fuel available had to be considered; the plant owner was quite willing to go along with a movement which would increase efficiency and reduce costs, but was not willing to spend what he might consider an unreasonable amount of money to replace serviceable equipment. On the other hand, the average householder did not want his home to be regulated at all. Under the circumstances, the type of ordinance evolved was as good as could be expected.

More than 125 American cities of 30,000 or more population now have some form of ordinance designed to minimize dense smoke. While these ordinances vary considerably in detail most of them have certain fundamentals in common, such as the limitation of the amount of dense smoke, the determination of density by comparison with a standard, the control of type of equipment to be installed, regulation of chimney size, and so on; and a form of penalty for violation.

The following extracts from the ordinance now in effect in Pittsburgh will serve as an illustration:

Section 2. The production or emission within the City, of smoke, the density or shade of which is equal to, or greater than Number three (3) of the Ringlemann Chart, from any stack, except that of a locomotive or steamboat, for a period, or for periods aggregating two (2) minutes or more in any period of fifteen (15) minutes and the emission of such smoke from any locomotive or steamboat, for a period, or periods aggregating one (1) minute or more in any period of eight (8) minutes, except for a period not to exceed twenty (20) consecutive minutes, not to exceed once a day, while a new fire is being built therein, is hereby prohibited.

Section 4. No Person or Corporation shall construct, install, reconstruct, alter or repair any furnace, boiler-furnace, stack or other apparatus connected with a stack, unless he or it shall make application in writing to the Bureau of Smoke Regulation . . . for a permit . . . and in and by such application shall give the plans and specifications showing the style and dimensions of the furnace [etc.], a description of the building or part thereof in which such furnace [etc.] is located, including the means provided for regulating the temperature of such building or part thereof and ventilating the same, and generally all provisions made for preventing smoke, together with a statement of the kind of fuel proposed to be used and of the operating requirements to be made of the furnace or furnaces referred to therein, and unless such application shall be passed upon by the Bureau of Smoke Regulation, and approved in writing and a permit issued as hereinafter provided; provided, however, that minor or emergency repairs . . . may be made without a permit.

Any Application shall be approved or rejected within ten (10) days after the same is filed in the office of the Bureau of Smoke Regulation.

Upon the approval of any application . . . the Bureau of Smoke Regulation shall issue a permit for the construction [etc.] of such furnace, boiler-furnace, stack or other apparatus.

In the event that any such application is rejected by the Bureau Chief, Bureau of Smoke Regulation, the Applicant has the right to appeal from his decision to the Advisory Board. . . . If a majority of the members of the Advisory Board present shall be of the opinion that the application [calls for changes which will not produce

Smoke Abatement Ordinances Should No More Exempt the Private House Than the Industrial Plant. Individually the Householder Is a Small-Smoke Producer; Collectively He Looms Large, Especially in Soft-Coal Regions

unlawful smoke], the decision of the Bureau Chief . . . shall be reversed and the finding of the Advisory Board shall be binding upon the Bureau Chief . . . . ; otherwise [it] shall be confirmed. . . .

Section 8. If any Person or Corporation shall violate any one or more of the prohibitions or requirements of this ordinance, he or it, shall upon conviction before any police magistrate or alderman of the City of Pittsburgh, be subject to a fine or penalty not exceeding one hundred ($100) dollars for each and every violation thereof, and each day's violation shall constitute a separate offense; or undergo an imprisonment in the Allegheny County Jail or Workhouse of not more than thirty (30) days, or both, at the discretion of the committing magistrate or alderman.

Results attained in the abatement of dense smoke have been progressive in direct proportion to the intelligent effort expended by enforcement officials and interested organizations, and with the education of the general public. There is increasing insistence that all reasonable efforts be made to prevent objectionable smoke. Whereas, only a few years ago, a smoky stack in a community was accepted as a necessary evil, when it now annoys complaint is made to the city's anti-smoke bureau, with a request that the nuisance be abated. The medical recognition of natural ultraviolet radiation, with respect to the maintenance and promotion of health, has had a favorable influence on the attitude of the public toward rational smoke abatement. The smoke abatement departments of a number of the larger cities are exchanging ideas and experiences, with a view to bettering conditions as far as possible with present-day ordinances. Plant operators are cooperating in a way that, a decade ago, would not have been expected. There is more careful selection of equipment and of fuels, closer supervision over methods of operation—which, of course, to the operator, means greater efficiency and lower fuel cost. With all this, the smoke nuisance, although not as great as formerly, is still present.

Existing vs. Future Regulations

The principal reason for this lack of complete success is that ordinances are made to control dense smoke only, and in most cities private dwellings and small apartment houses are exempt from regulation. Since air pollution, for which the combustion of fuel is responsible, consists not only of visible smoke but of solids that do not appreciably color the smoke stream, and, in addition, of noxious and obnoxious gases, it is obvious that smoke abatement, as it has been generally understood, is inadequate to cope with the problem. To continue indefinitely with the present system, making modifications only to suit the general run of available equipment, will mean that further progress will be slow.

On the other hand, what different provisions could an ordinance have that would make it as strict as is practicable at this time? This question is easily answered from experience: First, there should be no exemptions of private dwellings or small apartments. Second, fuel should be fed automatically to the firebox. And third, all stacks emitting gases of more than a given volume and/or at greater than a specified velocity should have dust separators.

Under the first and second of these ideal requirements, the owner of a dwelling, small apartment house, store or shop would have a choice among approved downdraft boilers and stokers for bituminous coal, magazine type feed for anthracite or coke, gas burners, and oil burners. Power boilers and the larger heating boilers would and should be stokered. All this equipment is now available.

It will be noted that the third provision exempts all stacks below a certain size. This is because separators are usually made for the intermediate and large size plants, and must be developed in what may be termed the domestic size at a price which will not be out of line with the cost—initial and operating—of the remainder of the plant. Due to the fact that the smoke which can be seen as it issues from stacks is blamed, generally, for all damage due to combustion products, the dust problem from plants has not received the attention it merits. No ordinance aiming at air clarification should be without a provision for the control of ash accompanying flue gases.

With an ordinance of the character outlined, there would be a far greater reduction of visible smoke than is now possible; and of perhaps three-fourths of the dust emitted by stationary plants. The winter smoke from heating plants would be reduced to a minimum; buildings would be cleaner, inside and out; a higher percentage of possible sunshine, particularly in the healthful, shorter wave lengths, would reach the street level; and a number of other benefits might be mentioned.

An additional aid would be the extension of the use of steam, generated in central plants, for heating and processing. This type of public service is growing and, especially in downtown sections of cities, has been productive of very marked results from the standpoint of smoke abatement. Even if the same amount of fuel were to be burned in a central plant as would be burned in the group of plants replaced, it would be under better control, usually a cheaper grade of fuel could be used, and there would be one stack to regulate instead of, perhaps, several hundred. The use of central steam may be economically possible where there is a sufficient concentration of buildings or of industries. The same is true of power and light generated at a central station instead of in individual buildings, each with its own power plant.

Smokeless City Will Come

The White City, entirely free of smoke and dirt from stacks, undoubtedly will come, and with it the benefits of which dwellers in cities—particularly industrial cities—are now deprived. Gas will be produced at mines conveniently located, and electricity will be generated at plants near mines and water. When this vision will be realized cannot be predicted. Meanwhile, solid, liquid and gaseous fuels must be used, and the effort made truly to prevent objectionable products of combustion from contaminating the atmosphere. Necessary development work should be carried on under proper leadership with the national engineering societies cooperating with manufacturers, fuel producers, research organizations, and smoke-abatement enforcement officers. The ultimate goal must be complete combustion in the furnace at all times, with the separation of all solids from the flue gases. In connection with the problem of effecting economically complete combustion, will the chemical engineer provide a suitable catalyst of practical value?

The subject of sulphur oxides and particularly sulphur dioxide as products of combustion of fuel has not been mentioned here as it is touched on elsewhere in this issue. The elimination of sulphur from fuel or the neutralization or/and removal of sulphur oxides from furnace gases are other problems for the chemical engineer.

Automatic Fuel Feeding for all Furnaces, Large and Small, Will Eventually Be Required in Smoke Ordinances of Urban Communities

Water—Raw Material For Chemical Industry

By

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For the last ten years the author of this article has been very actively interested in water treatment. After receiving his doctorate at the University of Chicago in 1916, Dr. Hall was connected with Carnegie Institute, the Chemical Warfare Service, as Captain, and the Koppers Company, until 1922. In that year he joined the Bureau of Mines where he worked on water problems until 1926. Since then he has directed the Pittsburgh laboratory bearing his name and has developed treatment processes for numerous water requirements

WATER which is employed as a raw material of processes requires certain attributes for maximum proficiency in its use. Whether the process be one of producing flawless sensitized film, manufacturing high grade paper, generating power, laundering or maintaining velvety texture in putting greens, quality of the water must be either controlled or compensated. Fitting attributes of one process may not be those of another, but in each case uniformity of these attributes is essential.

Owing to this requirement of uniformity, water treatment is a problem of diversity, inasmuch as natural waters from different sources vary widely in their characteristics, and that from any one source is subject to seasonal and aperiodic fluctuations of both dissolved and suspended impurities, and at times to drifting permanent change. The first-named changes are more characteristic of surface waters, and quite generally are roughly in inverse proportion to the volume of the source; the latter occurs in both surface and ground waters. Thus, the calcium content of the Allegheny or Monongahela River in the dry months of latter summer or early fall may be treble the annual average, but sinks to low value when winter rains and snowfall become effective. Meanwhile, in huge reservoirs of ground water, as in the Monongahela and upper Ohio basins, or in large lakes, as Michigan, content of calcium remains relatively uniform. In earlier days, the water of the Monongahela was bicarbonate in character; contamination by mine drainage and plant waste now renders it acid much of the time as it passes Pittsburgh.

Changes in amount of suspended and organic content in waters may be as abrupt, and as great or greater than those noted for the mineral constituents. From such a welter, water satisfactory for each process must be prepared.

Although impurities in water are legion in number and variety, comprising dissolved gases and dissolved and suspended mineral and organic matter, with the colloidal state frequently well represented, usually only certain more predominant components or special classes of substances must receive specific consideration.

Thus, of many gases present in natural water as traces, those present in quantity, and of activity sufficient to warrant their consideration in processing water for industrial purposes, are usually limited to oxygen, carbon dioxide, and at times hydrogen sulphide.

Of dissolved mineral constituents, those in general meriting consideration comprise the following radicals: Carbonate, bicarbonate, sulphate, chloride, nitrate, silica, iron, aluminum, manganese, calcium, magnesium, sodium, and potassium. The absolute and relative concentrations of these components may vary widely, but usually reflect the mineral characteristics of the parental drainage area. Silica presents an interesting problem as to whether it is dissolved or colloidal.

The composition of suspended mineral impurities may be anything, and their state of division may vary from that of discrete particles that readily settle to that of the true colloidal state, requiring specific treatment for procurement of agglomeration into flocculated form. Certain waters from the South, of low dissolved mineral content, furnish excellent examples of the latter.

Organic impurities represent a complicated mixture of the dissolved, colloidal and suspended states. Their removal to a satisfactory degree, whether by true flocculation, adsorption, or otherwise, is quite commonly a problem in flocculating materials and in pH values specific to the water involved and its intended uses. A successful solution to such a problem in the present state of knowledge still rests to some extent on cut-and-try, rather than on theoretically predetermined application of general principles. On such elimination may depend the desired quality of a fine fabric or high-grade paper.

Filtration With or Without Flocculation Will Often Suffice; These Gravity Filters Were Used for Emergency Municipal Service

Mineral and Organic Constituents

Direct Chemical Treatment—This form of treatment signifies direct addition to the water, as it is used, of substances which provide the water with preferred attributes for the use in question.

When establishment of essential pH values only is required, generally an alkaline chemical is needed and direct addition to the water of caustic soda, soda ash, or lime usually functions satisfactorily. In the Pittsburgh district, for instance, where many millions of gallons of river water are used daily by the steel industries for cooling pur-

poses, addition of lime roughly in proportion to the acidity and volume of the water results in satisfactory limitation of corrosion in the lines.

To minimize corrosion by recirculating brines as used in refrigeration, use may be made either of pH value control by alkaline chemicals (usually caustic soda), or of the protective-film forming (passivity) properties of chromates or bichromates.

Direct treatment for softening and detergent purposes in the home, laundries, dairies, and so on, is well cared for by phosphates, sodas, borates, and silicates, available on the market in convenient form, and by the special soaps widely used today.

In steam generating plants, direct-treatment based on requirements of the boiler water for the establishment of desired chemical equilibria is widely used, either by itself, or following one of the systems of treatment discussed later. Sodium hydroxide, carbonate, orthophosphate, metaphosphate, aluminate and sulphate are extensively used for the purpose. Direct treatment alone, or in conjunction with filtration only, finds economical application on waters whose calcium is low, either naturally or due to mixture with condensate.

Growth of organic matter on condenser tubes frequently seriously impairs efficiency of heat transfer, and renders necessary periodic cleaning which may be both costly and disagreeable. The application of very small quantities of chlorine provides excellent inhibition of this growth. Such examples are characteristic of the many applications of direct treatment.

Filtration—For many purposes, essential attributes of water comprise not softening, but a preferred pH value, clarity, and absence of iron and color. Textile and paper industries, and others in which direct contact of water with the product must leave no flaw, are examples. The end is attained by filtration, coupled with careful chemical control of reagents used to obtain the desired pH value, and of flocculating materials introduced to agglomerate particles of all degrees of fineness into aggregates. The filters may be of the pressure or gravity type. The permissible rates of flow are well established. Careful discretion is necessary in selection and grading of the filtering medium.

For some purposes, filtration merely through sand without flocculation suffices. At other times, when extremely high degree of clarity is necessary, utmost care must be exercised in choice of pH value for flocculation, and of reagents to produce flocculation. The flocculating materials in most common use are compounds of aluminum, as the sulphate, aluminate and the alums; and compounds of iron, as copperas, and at times chlorinated copperas and ferric chloride. Ferric aluminate has recently been made available for use.

Color Removal Difficult

Perhaps the most exacting problem arising in industrial filtration processes is removal of organic coloring matter by manipulation of pH values and flocculating reagents. Use of chlorinated copperas and ferric chloride has been attended with success. Whether the coloring matter is derived from the vegetation of New England or Florida, or the forests of Washington and Oregon, removal is difficult; and although it may be sufficiently complete to provide apparent absence of color in the water leaving the filter, concentration in a boiler usually results in deeply colored boiler water.

Softening Processes—By definition, soft water is "characterized by the practical absence of substances, as calcium and magnesium salts, which prevent formation of lather with soap." (Webster's New International Dictionary). One criterion of the softening process is thus removal of soap-consuming substances of which calcium, magnesium and iron are characteristic.

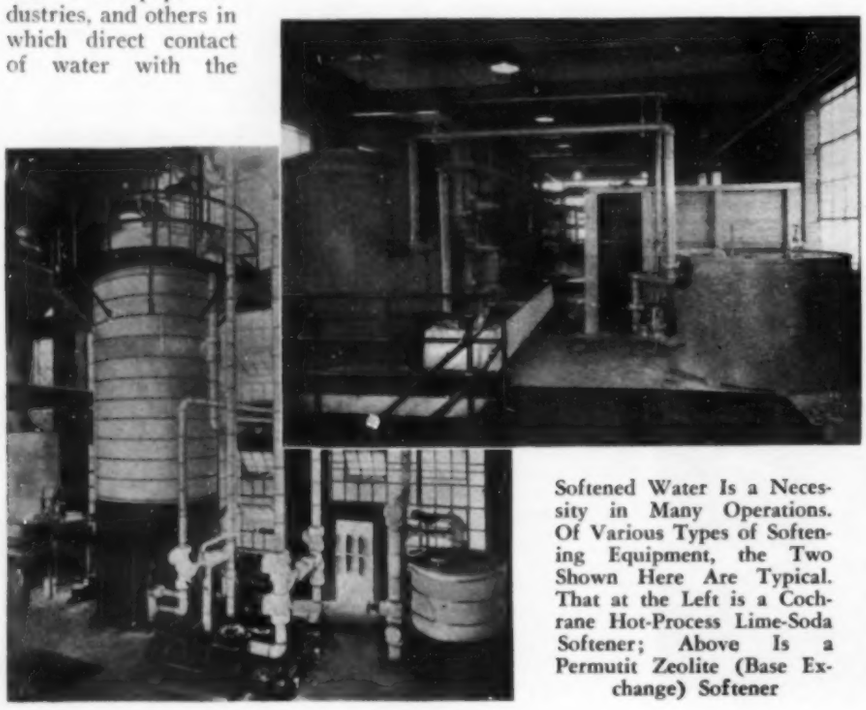
Quality of the water in such cases is frequently expressed in degrees of hardness as determined by the soap test. But for many purposes, softened water is evaluated not only in terms of soap hardness, but more comprehensively and critically by pH value, content of total dissolved solids, and by the characteristics acquired, and those imparted to another of its phases when concentration occurs through change of state as in manufacture of ice or generation of steam.

Two general methods of softening are in common use. In the lime-soda process, which may be either intermittent or continuous, hot (usually approximating 210 deg. F.) or cold, the removal of bicarbonate, together with calcium, magnesium and iron is effected by introducing into the water appropriate quantities of a soluble metallic hydroxide (alkali- or alkaline-earth-metal hydroxides) in conjunction with an alkali-metal carbonate (infrequently barium carbonate also).

In the base-exchange or zeolite process, bicarbonate is not removed, but replacement of calcium and magnesium by sodium is effected by passage of the water through a bed of zeolite mineral. Regeneration of the mineral is effected by alkali-metal chloride (or nitrate) brines. Softening occurs at any rate of flow up to a permissible maximum. The preferred temperature of softening is low—usually below 100 deg. F. At times, combinations of the two processes are used. For instance, bicarbonate in water of high temporary hardness may be removed by treatment with lime, while final softening is accomplished by the zeolite.

When use of the softened water involves a change of state, as in the generation of steam, direct treatment subsequent to the softening process is frequently advantageous, in that it makes provision in the residual water for the altered conditions of temperature and concentration of impurities.

Both processes remove calcium and magnesium to a satisfactory degree. Simplest and most economical attainment in the softened water of those other attributes requisite for its intended uses should decide the type of process in any specific case. In one class of uses, as in laundering, process work or cooling of condensers and internal combustion engines—uses which involve change of state of the softened water to a slight degree only, if at all—removal of calcium and magnesium is the major object of the softening process, and concentration of residual sodium bicarbonate and dissolved solids in the effluent



Softened Water Is a Necessity in Many Operations. Of Various Types of Softening Equipment, the Two Shown Here Are Typical. That at the Left is a Cochrane Hot-Process Lime-Soda Softener; Above Is a Permutit Zeolite (Base Exchange) Softener

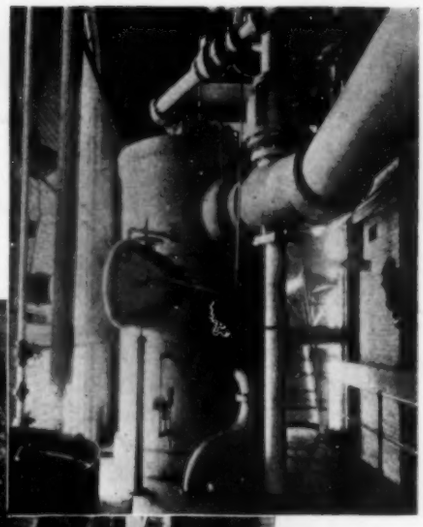
water from softener is of negligible importance. In the other class of uses—that in which the end sought is attained only by effecting change of state as in manufacture of ice or generation of steam—limiting the concentration of residual sodium bicarbonate and dissolved solids in the effluent water from softener is of primary importance. In the generation of steam, for instance, carefully controlled limitation of the boiler-water alkalinity, and of the concentration of solids, as well as of contaminating gases in steam produced, is essential.

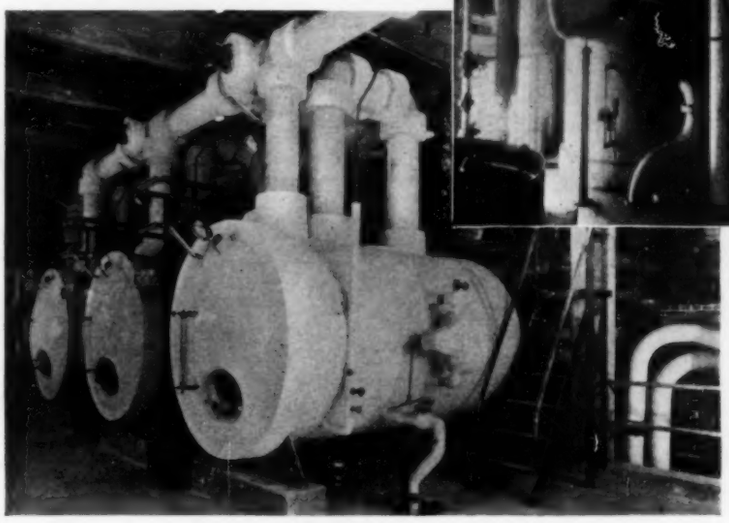
Electro-osmose Treatment—The electro-osmose treatment of water deserves mention, although it is as yet little utilized commercially. It removes salts from water through diaphragms by use of the electric current.

Evaporation—Water of the purity obtained by distillation has many uses ranging from those in the chemical laboratory and in the manufacture of ice to preparation of various products of the highest purity. Water purification by evaporation finds its most extensive application and development in steam generating stations. The evaporators used are sometimes single-, sometimes multiple-effect; and some of them operate at high-heat, others at low-heat level. In some cases, their feed water is treated by one of the softening processes, or directly; in others, scale that forms is cracked off by turning cold water into the heating coils. Economic adaptation to requirements of the individual station dictates procedure.

During the past several years, developments in steam generating practice have come rapidly. Higher pressures, higher ratings, larger boilers, water-cooled sidewalls and screens, demands for higher efficiency and certainty of uninterrupted operation, all have presented problems. Central stations, having high percentages of condensate return, and therefore low percentages of make-up water, have with but few exceptions preserved the purity of boiler waters by evaporating make-up water.

In case of considerable make-up water, as in the steam-generating station of an industrial plant, it was once thought that evaporation was necessarily concomitant to adoption of higher pressures. Boilers have, however, been developed to the point of handling more concentrated waters at higher rating without detriment to steam quality; continuous blowdowns of the flash and heat-exchanger types have permitted more leeway in blowdown without serious loss of heat; development of exactness in water conditioning has banished fear of outage because of scale formation on highly heated surfaces. It has now been proved in practice that for operating pressures up to and somewhat above 600 lb., and even with total make-up water, evaporation is a matter of choice and not of necessity. And although evaporation results in purity of boiler waters, the pH values and chemical ratios which are imperative for avoidance of deterioration of the boiler metal must be maintained by direct treatment.





Some Treatment Steps Require Distilled or De-aerated Water. Below Is an Installation of Three Foster-Wheeler Evaporators; at the Right an Elliott De-aerating Heater

Dissolved Gases

Removal of dissolved gases from water is accomplished: (1) mechanically, through operation of the laws of partial pressure; (2) chemically, by fixation; or (3) by a combination of chemical and mechanical means.

Mechanical Means—In equipment for gas removal by mechanical means, dispersion of the water into drops on entry into the apparatus assures the molecules of gas a short path of escape from liquid to vapor phase. The vapor phase may originate in flashing of the liquid itself, or from steam in excess of that required for heating the liquid. Continuous removal and renewal of the vapor phase must occur to the extent necessary to maintain in the vapor in contact with the water a very low partial pressure of the gases to be removed.

Oxygen, which obeys the laws of Henry and Dalton, may be very completely removed in this manner, and carbon dioxide also, in so far as it obeys these laws. Thus in a tight turbine-condenser system, both oxygen and carbon dioxide are removed by the air-ejector; but when water containing half-bound carbon dioxide passes through the heater, the time factor is too slight to permit more than partial breakdown of the bicarbonate.

Fixation—When it is important to remove the last trace of oxygen, fixation by a ferrous salt is now most commonly employed. This step should follow as complete removal as possible by mechanical means. It should also be noted that removal of both dissolved carbon dioxide and that half-bound as temporary hardness is effected by treatment with lime as the first step in the softening process. Finally, when sulphides are present their removal may be effected by use of a ferrous salt in the flocculation for filter or softener.

Combination Means — Undesired sodium bicarbonate may be present, at times in natural waters, and at others in those in which calcium and magnesium of temporary hardness have been replaced by sodium in the treating process. In natural water, this bicarbonate may be removed along with calcium and magnesium by use of calcium sulphate in addition to lime and soda. If calcium and magnesium have been previously removed by treatment, decomposition of bicarbonate is usually effected by acid treatment, whereupon the carbon dioxide, now obeying the laws of Henry and Dalton, is removed by washing with air, or in a de-aerator.

Organic nitrogen in natural water may become ammonia in steam generated from the water. When the water is treated with chlorine, however, transformation of organic to elemental nitrogen occurs, and removal may be effected on the basis of the partial pressure laws.

In conclusion, it should be noted that, inasmuch as adaptation of these principles to the specific requirements of any one process constitutes a distinct problem in itself, the scope of this discussion has necessarily been limited to general principles. But the proper application of these principles will effect uniformity of desired attributes in waters of greatly diversified characteristics.

Assuring Quality in Public Water Supply

By

JOHN R. BAYLIS

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Dorr Traction Clarifier in a City Water Filtration Plant

FILTRATION for the purification of a public water supply was first applied by the Chelsea Water Co., of London, in 1829. Even prior to this date, household filters were in use in some of the homes or other buildings. The early municipal plants were what are now known as slow sand plants. The water received no chemical treatment, and was passed slowly through beds of fairly fine sand. In most instances this produced a satisfactory product, or what was regarded as a satisfactory product years ago. Slow sand filtration has developed very slowly in the United States, and since 1910 very few such plants have been constructed.

The first rapid sand filtration plant constructed for a municipal water supply, which used a coagulant as a part of the process, was constructed at Somerville, N. J., in 1885. Since that date developments in such filtration have been rapid. At the present time nearly 2,000 public water supplies are using the rapid sand process. These plants vary in size from a capacity of only a few thousand gallons per day to 250,000,000 gal. daily. Of the larger cities using the rapid sand process, 50 have a total filtering capacity of 3,250,000,000 gal. daily. Nearly one-third of the total population of the United States, and perhaps in excess of one-half of the urban population, is supplied with filtered water at the present time. Probably 90 per cent of the water now being filtered has been chemically treated before filtration.

What the Public Wants

If every water works complied with the wishes of the public regarding the quality of its drinking water, there would not be a single one supplying water that was not of very high quality. Consumers do not want economy at the price of quality; they are perfectly willing to pay a fair price for water that is clear, pure and palatable. Satisfaction has a value which, although difficult to estimate, is much greater than the cost of purifying the water.

The bacterial standard for drinking water requires that it shall contain not more than one *Bacillus coli* per 100 cc.

Since 1907, shortly after his graduation from Mississippi Agricultural and Mechanical College, Mr. Baylis has been active in sanitary chemistry and engineering, principally in the field of municipal water supply. He is a member of numerous societies and committees, and chairman or past chairman of several. Since 1926 he has served as physical chemist for the Division of Operation, Bureau of Engineering of the City of Chicago, in charge of experimental work on filtration of Lake Michigan water

This is interpreted by those operating water-treatment plants to mean that the water should rarely exceed this figure. Most of the filtration plants are striving to reduce the *Bacillus coli* content to a point where it will average less than one organism per 100 cc. The water must be perfectly clear to be entirely satisfactory, and most plants are now trying to reduce the turbidity to about 0.2 part per million. Water with a turbidity that does not exceed this figure is clear enough for any industrial use.

Probably the public is more exacting in the taste of water than in any other quality. Palatable spring water in bottles has a ready sale in many cities where the water occasionally has objectionable tastes. This applies to waters that are filtered as well as to unfiltered supplies. The removal of certain tastes and odors in water has been quite difficult, and only within the past two or three years has it been possible to eliminate practically all kinds of tastes and odors likely to be present in a water supply. Water supplied the consumers through the city mains is a non-competitive product and, consequently, much depends on the attitude of those in charge of the water works as to the quality, other than the bacterial purity of the water. Health departments usually insist on the bacterial purity being up to standard. But water purification chemists and engineers are, in most instances, measuring up to their responsibility and producing water very close to that desired by the consumers.

Chemical Treatment Usually Essential

Rapid sand filtration depends almost entirely on the water being prepared for filtration by chemical treatment. With sand of about 0.5 mm. size, it is evident that bacteria and other fine, suspended particles are many times smaller than the openings through the sand bed. If it were not for the fact that these particles are entrapped within the coagulant which has been added for this purpose, it would be possible to remove only a portion of them by filtration. Where the problem is one of clarification and the removal of bacteria, as is the case in most water supplies, only a coagulant may be necessary. This assumes that the water has sufficient natural alkalinity to react with the chemical added, for otherwise an alkali also will have to be used. Where the water is softened, the process is more extensive, but the use of a coagulant in addition to the softening agent is almost invariably a necessity.

Aluminum sulphate is the most extensively used coagulant. Ferrous sulphate is used in a small percentage of the plants. Now that it has been found possible to produce ferric salts from the sulphate by adding chlorine to a solution of ferrous sulphate, we may expect an increase in the use of iron in water treatment, although it may never be a serious competitor of aluminum sulphate.

Practically all coagulants used in water treatment depend on the production of a hydrous oxide of alumina or iron. These oxides precipitate in gelatinous form, and in the formation of the precipitate entrap the suspended particles composed of mud, bacteria, and any other finely divided material that happens to be present. Hence the filters are called upon only to remove relatively large masses that may contain hundreds of the finer particles in addition to the coagulant. Not only does coagulation improve filtering but it so improves sedimentation that the coagulated masses will settle quite readily if permitted to remain for a few hours in a basin where the flow is undisturbed and very slow.

Adding the Chemicals

Chemicals should be applied to the water continuously in the desired proportion so that each gallon of water will receive its required amount. This means that there must be devices that will add reagents uniformly in proportion to the flow of water. It also means that such devices must be so constructed that the quantity of chemicals may be changed very rapidly. There are two general methods of supplying the reagents continuously. One is to make a solution of a definite strength and feed it through an orifice or other feeding device, and the other is to measure the chemicals in the dry form. Where the solution feed is used, an orifice under constant head is a very accurate means of proportioning the flow.

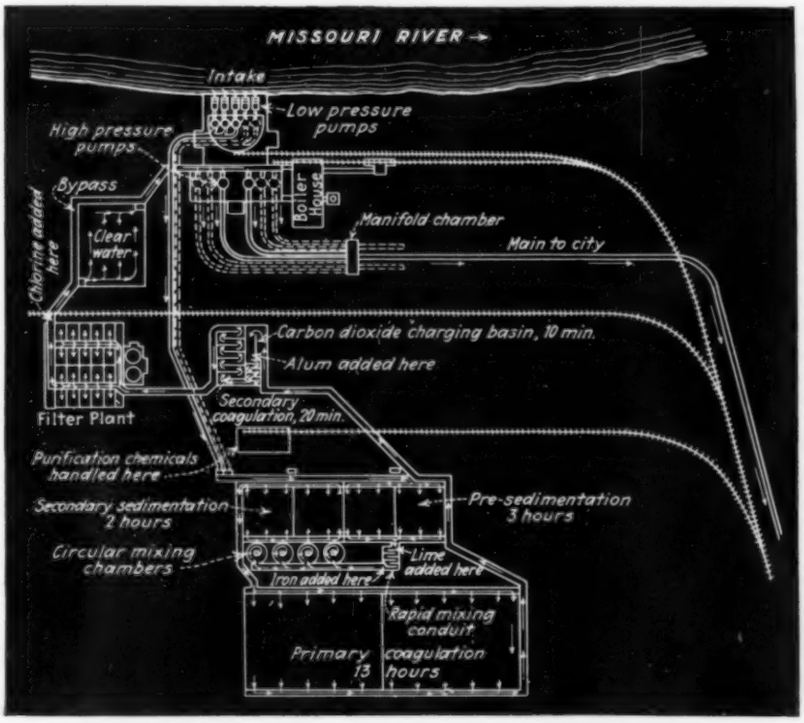
City Water Plant at Kansas City; Note Traction Clarifiers for Preliminary Settling and Large Basins for Final Sedimentation After Coagulation

Most of the machines for measuring the chemicals in the dry state work on a volume-measurement basis. When the volume-weight relation is fairly constant these machines will measure very accurately. In nearly all instances where the chemicals are supplied in this manner they first fall into a dissolving box where a constant flow of water dissolves and carries them to the water to be treated. Lime, when it is used, is ordinarily only partially dissolved. The saturation point of calcium hydroxide is quite low in comparison with coagulants such as alum and ferrous sulphate, and it is usually desirable to handle a lime suspension rather than a volume of water large enough for complete solution. Very few plants are now being equipped with solution feeding apparatus. Dry feeding machines are proving so reliable that it probably is only a matter of time until they will almost entirely take the place of solution feeds, except where some unusual condition makes the latter desirable.

Usual practice in rapid sand-filtration plants, after the addition of the chemicals to the water, is to pass the water through a mixing basin. This keeps the water in motion, first to mix the chemicals thoroughly with the water, and then to flocculate the coagulated particles. The motion should be sufficient to keep the flocculated particles from settling, yet if it is too great the large flocs so desirable for rapid sedimentation will not be formed. The velocity in most mixing basins ranges from 0.5 to 1.5 ft. per sec.

Almost any device that insures quick and uniform mixing, and keeps the water in a state of motion for a period varying from 10 to 60 min., is suitable for a mixing basin. Customary practice is to build a rectangular basin and insert wooden or concrete baffles so that the water flows back and forth in a horizontal plane or over and under the baffles. Mechanical mixing has been used more extensively within the past few years. There are indications that it gives slightly better results than a baffled basin and is no more expensive to construct and operate.

Layout of New Missouri River Water Supply Plant of the City of St. Louis; This Is an Outstanding Example of Modern Filtration-Plant Design



Sedimentation

After coagulation, the water in most municipal filtration plants is passed through settling basins. There a large part of the coagulated matter settles out. The time of settling varies widely in different plants, but most of them have basins that give a settling period of from two to six hours. Four hours' settling is regarded good practice, although the character of the water and the method of treatment have some influence on the most economical settling time. Turbid waters after proper coagulation settle most of the coagulated matter within two to four hours. Most rapid sand-filter beds will handle water ranging in coagulated turbidity from 10 to 50 parts per million and produce perfectly clear water, although it is desirable and usually economical to reduce the turbidity of the coagulated water to about 5 to 10 parts before it goes to the filters. Some waters are not easily filtered clear when the temperature is near the freezing point and the coagulated turbidity is more than about 10.

It is usually more difficult to get good sedimentation when the raw water is fairly clear than when it is turbid. The flocs produced by aluminum sulphate and by ferrous sulphate are very light and do not have much tendency to

settle when there is little or no suspended matter in the water to add weight to the flocculation. It is usually easier to handle a turbidity of 25 to 100 than a turbidity of 5 to 10, although more chemicals are required to coagulate the higher turbidity.

It is customary to have two or more settling basins in a filtration plant so that one may be out of service for cleaning without interfering seriously with the operation of the filters; that is, without throwing more coagulated matter on the filters than they will handle. Continuous sludge-removing devices are beginning to be used where there is considerable sediment, especially where the water is softened and there is a good deal of calcium carbonate precipitated. Where water contains considerable suspended matter, it is likely that such devices will be used extensively in the future.

Filtration

Sand beds are now only a part of the purification process. With the coarse sand and the high rates of flow now used it is essential, as has been explained, that the water be prepared for filtration. Filters, like buildings and bridges, should have a factor of safety. The quantity of coagulated matter going to the filter beds should be not more than one-third to one-fifth of the amount the filter will actually handle and still filter the water perfectly clear. Nor should the maximum rate of filtration be more than about one-third of the rate at which water may be passed through the bed and still filter clear. To meet these requirements filters are usually given a rating of 2 gal. per square foot per minute, and the amount of coagulated matter going to the filters is usually reduced to less than 10 to 15 parts per million.

The sand beds are supported on a bed of graded gravel from 12 to 18 in. in thickness. Gravel about 1½ to 2 in. in diameter is ordinarily used for the bottom layer, then this is followed by three or four more layers of gravel, each being finer than the preceding one, until the top layer is composed of gravel only about ¼ in. in diameter. The drainage system is located just beneath the gravel or within the gravel near the bottom of the coarsest material. There are several forms of underdrain, most of which are suitable. The main factor in laying out the underdrainage system is to construct it so that a uniform amount of wash water will be delivered to all parts of the bed when the filter is being washed.

Sand beds are usually 24 to 30 in. in thickness, and are composed of sand which has an effective size of 0.35 to 0.6 mm. in diameter. By effective size is meant the size of grain such that 10 per cent by weight of the particles are smaller and 90 per cent larger than itself. The grain size should be fairly uniform, with a "uniformity coefficient" not greater than 1.5. This is a term used to designate the ratio of the size of grain which has 60 per cent of the sample finer than itself to the size which has 10 per cent finer than itself. Sometimes the size in which 1 per cent by weight of the grains are finer is specified, for it is desirable that the filter be of low resistance and contain no very fine material.

Interior of Filter Room in Water Plant at St. Paul, Minn.; Note Wallace & Tiernan Chlorine Control Equipment at Left of Illustration

It is desirable to have filter runs of about 24 hours or more, even though shorter runs are frequently encountered. Most of the filtration takes place in the upper 3 to 6 in. of the sand. Where there is an abundance of microorganisms of certain forms, especially the filamentous organisms, the filtration may be largely at the surface of the sand. This produces short filter runs, sometimes so short that it is impossible to operate the filters efficiently. When the runs are shorter than about 10 to 12 hours, many plants have adopted the procedure of giving the filter beds a reverse-flow agitation with the wash water, without actually washing, so as to break the tough surface that has formed over the sand. As the filter is not washed, no water is lost. When it is properly done, reverse-flow agitation of the beds will not increase the turbidity of the filtered water.

Washing the Filters

Filters are washed at various rates. A few plants use air to aid in breaking up the sand, but most of the plants now use what is known as the "high-rate-of-water" wash. Where air is used the rate of washing may be as low as 8 to 12 gal. per square foot per minute, and where water only is used the rate is usually 15 gal. or more. The tendency is to increase the rate of washing, and a few plants are using rates in excess of 20 gal. per square foot per minute. The evidence is that 20 gal. is near the most desirable rate for sand of 0.4 to 0.5 mm. for the 10 per cent size. The time of washing varies from about two to five minutes, depending upon the turbidity of the wash water. When the runs are short, two minutes may be sufficient, but with runs of from 60 to 100 hours, it usually requires from four to five minutes to wash the bed clean.

A few filters are now provided with floc detectors for observing the clarity of the filtered water. These instruments are of great value for waters in which the flocculation is weak and likely to pass through the sand beds after the loss of head has run up a few feet. The flocculation is likely to be weak in any water when the temperature is below about 40 deg. F. The cause for this weakness is not definitely known. Temperature has some influence, but it is not the major factor. To avoid passing flocculated matter, filters frequently have to be washed at 3 to 4 ft. loss of head in the winter months when the flocculation is weak.

Chlorination

Chlorine has now become an essential part of every treatment plant handling surface water, or where the water is likely to be polluted. Practically all filtration plants are now operated with the least amount of coagulant that will cause the water to filter clear, and chlorine is relied upon to reduce the bacteria to the desired standard. Where the water is not highly polluted, it is usually possible to add enough chlorine to the water after filtration to sterilize the water and not give it a chlorinous taste. For highly polluted waters the chlorine should in most instances be added to the water prior to filtration, and preferably at the beginning of the treatment process. There is no limit to the number of bacteria that may be handled with chlorine. When the pollution is unusually high an excess of chlorine should be added and the water later dechlorinated.

The first use of chlorine for sterilization was in the form of hypochlorite of lime. Liquid chlorine has now almost entirely superseded "hypo" in water treatment. Chlorine is purchased in the liquid form in steel cylinders. It vaporizes when the pressure is released and usually it is only necessary to have a machine for measuring the chlorine

gas. Most machines for this purpose have been manufactured by the Wallace & Tiernan Co.

There are no special requirements for most of the water used in industrial plants. Boiler uses, washing and cooling make up the greater part of the water used by industries. There are many cases, however, where part of the water goes into the product manufactured and may require water of a certain quality. Water used in the canning industry and in certain foods must be free from compounds that will impart an objectionable taste to the product.

It cannot be said just where the responsibility of the water works ends, nor when manufacturers should give the water additional treatment for their own particular needs. Very soft water is desirable for boiler and for laundry purposes, yet for a municipality to attempt to treat a hard water sufficiently to make it suitable for such purposes would be expensive. Nevertheless, all consumers will profit by partially softening a very hard water. Usually it is economical for a municipality to soften to a hardness between 50 and 100 parts per million; beyond this point it should be the problem of those desiring the softer water. It may be expensive to reduce the hardness of a certain water below 100, whereas another may be reduced to 50 at a reasonable cost. It is believed that municipalities should soften any water having a hardness in excess of 100 parts.

Other Objectionable Constituents

Removal of suspended matter, bacteria, and hardness has already been discussed. Turbidity and bacteria are encountered in all surface waters, and although the removal of these has been the main purpose of filtration, there are other objectionable constituents likely to be present in water. Iron and manganese occur to an objectionable extent in some waters. Removing these compounds should be regarded as the duty of the water works.

Probably the most objectionable constituent of water of natural origin, other than turbidity and bacteria, is the taste produced by micro-organisms. A large percentage of surface waters have, at times, very unpleasant tastes from this cause that cannot be removed by ordinary treatment in filtration plants. There are several methods of combating or removing these tastes. The two which have been used to the greatest extent in the past are aeration and the use of copper sulphate to kill the growths in reservoirs. Recently chlorine and chloramine have been used in the place of copper sulphate.

Considerable attention is now being given to the use of activated carbon for the removal of algae tastes. It is being used in two ways. One is to add the powdered material to the water and later remove it by filtration. The other method is to pass the water through a bed of granular activated carbon. Super-chlorination, followed by dechlorination, offers some possibility as being practical for the removal of such tastes. It is believed that the most satisfactory method is by the use of activated carbon, for when enough of the material is used the taste is removed so completely that it cannot possibly be detected.

Color Frequently Encountered

Color is an objectionable constituent of many waters. Ordinarily the usual coagulation and filtration processes remove it to a point where it is not very objectionable. Highly colored waters may have to be treated with an excess of the coagulant over that necessary merely to remove the turbidity. The color apparently is negatively charged and is adsorbed by the hydrous oxides of alumina and iron.

Decomposing vegetation frequently imparts a musty or moldy taste to the water. Such tastes are not easily removed by filtration. The storage of water for several weeks in open reservoirs usually eliminates musty and moldy tastes to a considerable degree. Activated carbon is very effective in removing such tastes, and frequently super-chlorination will improve the water materially.

Turbidity, bacteria, tastes from micro-organisms, hardness, color, iron, manganese, and tastes from decomposing vegetable matter constitute practically all the objectionable constituents of natural origin likely to be present in waters used for municipal supplies. Other contamination comes from waste products of manufacturing industries and from sewage. Most every manufacturing plant has some kind of waste product. Fortunately most of these wastes are easily disposed of, or are inoffensive to water supplies.

Taste elimination in water purification plants has now progressed to the point where water with considerable pollution by certain compounds can be handled very satisfactorily. Chlorophenol tastes, which have caused a good deal of trouble in the past in certain water supplies, can be prevented by the use of chloramine for sterilization. The phenols also can be removed by activated carbon, or the compounds changed to inoffensive ones by super-chlorination. Phenol may now be regarded as a compound not difficult to handle. This does not mean, however, that byproduct coke-oven plants should relax in their efforts to avoid contaminating public water supplies, for the removal of phenol from the water involves some expense. The matter can probably be solved most economically by cooperation between coke plants and the water works. In some localities it is decidedly cheaper to treat the water, whereas in other places it is cheaper for the industrial plants to eliminate the phenols.

Oil wastes are quite difficult to handle in a water treatment plant. Usually the taste and odor are reduced by aeration, but it is almost impossible to prevent their being noticeable. Activated carbon is probably the only means of eliminating oil-waste pollution completely, and this process appears to be fairly expensive if there is very much of the waste. Waste products from creosoting plants have given trouble in some water supplies, and the oils used on roads also have caused trouble occasionally. The increasing use of oil may make this problem more serious than it has been in the past.

Waste products that cause offensive tastes and odors when present in extremely minute quantities usually do not impart undesirable constituents to the water after the taste and odor have been removed. On the other hand, acid mine wastes and acid liquors from industrial plants are easily neutralized with an alkali, but this increases the salt content of the water. If the amount of acid is small, this may not be objectionable. Waste liquors from canning and other food plants are usually high in organic materials. If the organic content of the water into which they are discharged is not materially increased, and if all the dissolved oxygen is not used up, such wastes are not very objectionable where they do not impart a taste to the water. It is rather like the pollution of water with sewage, except harmful bacteria are not present. But obviously, a water supply can receive only a small amount of such liquors without giving rise to some objections. Generally the difficulty is largely the increased cost of treating the water for domestic uses. It is, of course, possible to take sewage and eventually to convert it into palatable drinking water—and about the only change that will be noted is an increase in the salt content. It is not economical to use sewage for the drinking water supply in localities where purer water is available, but it illustrates what might be done in regions where water is very scarce.

Pollution Limit Not Reached

Water treatment is keeping pace with other industrial progress. Although population will increase in certain sections of the country, and the watercourses will become more highly polluted, treatment processes will still be able to turn out a pure and palatable product. The limit of pollution that may be handled has not been reached in any part of the United States, although it is occasionally more economical to abandon a polluted supply for one less polluted. With reasonable cooperation from the industries with wastes to dispose of, there is no occasion to fear that our water-purification plants will not be able to produce a product of the desired quality.

Modern Sewage Disposal Exemplifies

By
FLOYD W. MOHLMAN

One of the country's leading authorities on sewage disposal, Dr. Mohlman since 1919, has served with distinction as chief chemist and director of the laboratories of the Sanitary District of Chicago. His pioneer work on the activated sludge process began with Illinois State Water Survey in 1912.

MODERN sewage-treatment plants are developing into complex assortments of screens, tanks and mechanisms, far different from the stereotyped settling tanks and trickling filters of ten years ago. A most profound change in development has occurred within the past five years, particularly with respect to the collection and use of combustible gas, produced by the decomposition of sewage solids, for heating the digesting sludge in insulated, gas-tight digestion tanks. The mechanization of sewage treatment has also included other types of sewage-treating equipment. Screens are now mechanically operated, with automatic control, grit is removed and washed mechanically, settling tanks are cleaned by plows or scrapers, aeration tanks are being modified to use mechanical agitators, sludge is being de-watered by vacuum filters and dryers, or scraped off sand beds by huge Juggernauts, and chlorine is used in a variety of ways not even contemplated five years ago. The scientific control of all phases of sewage treatment has resulted in greater efficiency and a more uniform and complete degree of treatment.

The cost of sewage-treatment works built in the past five years and contemplated in the next eight is staggering. Chicago is far in the lead, with a completed expenditure of $96,000,000 and a $169,000,000 program in the next eight years. This future program is definitely established by order of the United States Supreme Court, and expenditures for future construction are allocated for plants now being built or in process of preliminary design. New York's first large plant, at Ward's Island, will cost approximately $19,000,000. Milwaukee's activated-sludge plant cost $9,000,000, plus $18,000,000 for intercepting sewers. Cleveland has voted a bond issue of $14,000,000 for an activated-sludge plant. Many other large treatment works, costing from $1,000,000 to $5,000,000 have been built in the past decade.

This tremendous expenditure has resulted in intensive search for the most efficient, most economical and most complete combination of processes for accomplishing the required degree of treatment. Sewage is treated to whatever degree is necessary in order to satisfy the requirements for disposal. Discharge into the ocean, as at Atlantic City, N. J., and Long Beach, Calif., or into large tidal rivers such as the Hudson at New York, may require only fine screening, with proper dispersion of the effluent.

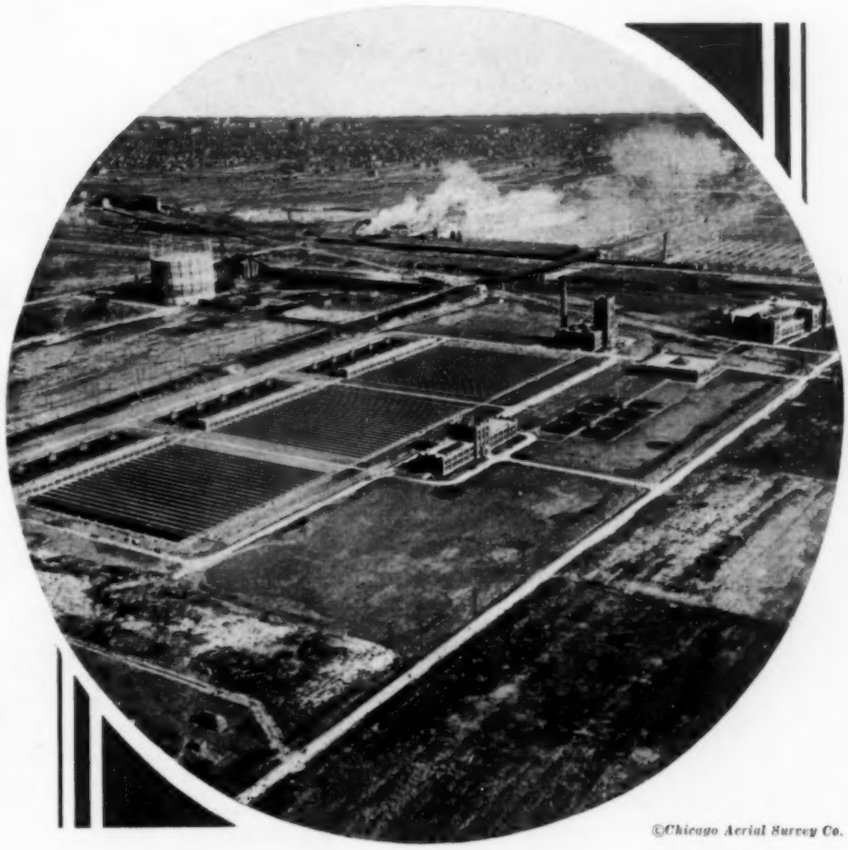
Fine screens usually have slots ⅛ to ¼ in. wide by 2 in. long, which act simply as strainers. In view of this limited action fine screens are rated as capable of accomplishing only 5 to 10 per cent removal of the suspended solids of the sewage. They are used, however, prior to activated-sludge treatment at Milwaukee and Pasadena. Screens at Indianapolis act more as concentrators, since the solids are not removed from the screen surface, but are washed out of the chamber with from 10 to 15 per cent of the sewage flow, and settled in mechanically-cleaned settling tanks.

It is always desirable to remove gritty or sandy material from sewage before entrance into settling tanks. This removal is effected by passage through chambers from 40 to 80 ft. long and of such cross-section that the velocity of flow will be approximately 1 ft. per sec. In new plants, at Akron, and the Chicago Sanitary District West Side Works, approximately 15 per cent of the underflow from preliminary-settling and skimming tanks is passed through grit chambers, thus greatly reducing the number required. Unless this is done a large number of chambers must be held in reserve in order to cope with the greatly increased quantities of grit brought down by storm flows in combined sewers. Other plants recently installed (High Point, North Carolina, and Aurora, Ill.) use square "detritors," in which the grit is plowed continuously to a channel in which it is washed and discharged. Another type of rectangular grit chamber contains plows which scrape the grit to both corners of the inlet end, where screw conveyors carry it up an incline and out of the tank.

After the grit is removed the sewage is ready for settling to remove as much as possible of the organic settleable solids. The grit is undesirable in settling tanks, since it packs into the bottom of the tank and must eventually be removed by hand from Imhoff tanks, as was necessary at Fitchburg, Mass., or it may interfere with the scraping or plowing mechanism of settling or digestion tanks, if such mechanism is not operated continuously.

Settling of sewage solids is not so simple as settling of inorganic suspensions. Settled-fresh sewage solids decompose and form gas which buoys up the sludge, if not removed, and allows it to escape with the effluent. Such action is prevented in the Imhoff tank, in which the settling solids slide down a sloping baffle to a lower chamber, which is trapped from the upper by a slot below which is a long triangular beam. The gas escapes through longitudinal gas vents alongside the flowing-through compartment. Solids digest in the lower compartment to a black, gas-filled, odorless sludge containing from 87 to 92 per cent water.

Plain settling tanks can be used for clarification of sewage provided the settled solids are removed from the bottom of the tank continuously, or nearly so. This is not feasible in plain tanks even with hopper bottoms, but by use of mechanical plows or scrapers the sludge may be removed continuously and completely. The use of such tanks has become almost universal for plain



Largest Activated-Sludge Plant in the World. Treating 200,000,000 Gal. Per Day. North Side Treatment Works, the Sanitary District of Chicago

settling, but the removed solids must be digested in the same way as is accomplished in the lower compartment of an Imhoff tank before they can be disposed of without nuisance. Separate digestion in auxiliary tanks is therefore necessary with mechanically-cleaned vessels.

Settling tanks are usually designed with a detention period of from one to three hours. The removal of suspended solids varies from 40 to 60 per cent and the reduction of the biochemical oxygen demand varies between 30 and 40 per cent. In many cases this partial treatment is all that is required. If the oxygen demand of the settled effluent is less than the available oxygen present in the receiving stream, so that the dissolved oxygen is not depleted to zero, nuisances due to odors will not develop. If the dilution is so low in summer that all dissolved oxygen is gone, more complete treatment is indicated.

In some cases, such as along lake shores and in harbors, the situation may call for bacterial reduction in addition to a favorable oxygen balance. Removal of bacteria from settled sewage is best accomplished by chlorination, as practiced at the Westerly plant in Cleveland and along the North Shore at Chicago. Complete treatment plus chlorination, however, is more effective and more positive than sedimentation plus chlorination.

Complete treatment does not mean 100 per cent removal of the suspended solids, biochemical oxygen or bacteria, but approximately 85 to 90 per cent, based on the sewage actually treated. It is practically impossible to treat all sewage discharged from a system of combined sewers in large cities, consequently some sewage in stormwater always escapes treatment. For this reason and taking account of small and isolated sewers not connected with the interceptors, an over-all efficiency of 85 per cent may be considered as the maximum practicable.

Two processes of complete treatment are now in use: (1) activated-sludge and (2) trickling-filter. Trickling filters are designed almost exactly the same as was the custom 20 years ago, but the activated sludge process, which has been developed from bottle-scale experiments in the past 18 years, has naturally undergone various changes and improvements. For example, it is now customary to provide preliminary-settling tanks prior to the aeration tanks, as first exemplified in this country at the large North Side Treatment Works in Chicago, and contrasted with the use of fine screens preceding the aeration tanks, as at Milwaukee and Pasadena. Another change of importance has been the arrangement of porous plates, for air diffusion, along one side of the tank rather than in furrows across the tank, separated by 45-deg. concrete ridges. The so-called spiral-flow type of aeration has resulted in a saving of plate area and a reduction of approximately 20 per cent in the volume of air required. This is a tremendous saving, since the power required for air compression is the main expense, aside from labor, in the operation of an activated-sludge plant.

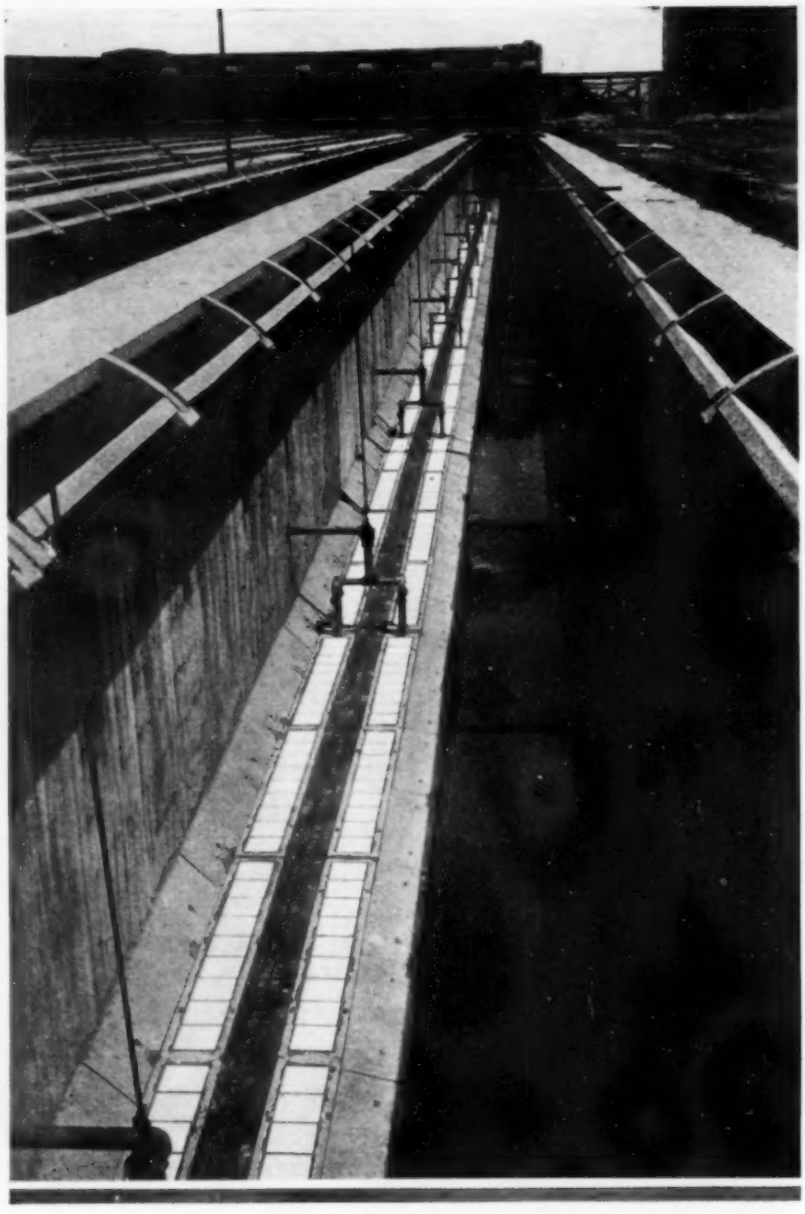
Many types of mechanical devices have been used for obtaining the intimate mixture of air, activated-sludge floc, and sewage required for successful treatment. It has been known since 1915 that only 10 to 15 per cent of the oxygen in the air applied is actually required to satisfy the oxygen demand of the sewage, with the remaining 85 to 90 per cent used for agitation. Since agitation by air is notably inefficient as compared with mechanical stirring, various devices have been used for agitation, with air introduced either through porous plates or absorbed from the surface. The mechanical devices that have been tried include downward circulation by turbines through a central draft tube, upward circulation with discharge as a spray, circulation through long channels induced by paddle-wheels of the old "stern-wheeler" type, and spiral-flow circulation induced by paddles attached to a longitudinal shaft extending the full length of the aeration tanks, with auxiliary air supplied

through porous plates which serve to diffuse the air.

An outstanding development of the past five years has been the ascendancy of the activated-sludge process over trickling filters for large plants. Although these filters are better able to stand variations in quality of applied sewage, and temporary overloads, than the former process, and are low in operating cost, they are usually inferior to the activated-sludge process in quality of effluent, freedom from odor and flies, and area required.

It is rather surprising to note this swing toward the activated-sludge process because of the superior quality of the effluent, rather than because of the recovery of fertilizer value in the sludge. Fifteen years ago those who were working with activated sludge at Milwaukee, Chicago, and Urbana were more intrigued with the possibility of recovering a marketable fertilizer than with the production of a superior effluent. Fertilizer is, of course, being produced at Milwaukee, Pasadena, and (on a small scale) at Indianapolis and Houston. But other cities, including Chicago (North Side, Calumet, West Side, and probably Southwest Side); North Toronto, Ont.; Springfield and Peoria, Ill.; Elyria, Cleveland (Easterly), and Salem, Ohio, are operating or contemplating the construction of plants in which activated sludge is disposed of by digestion and drying on sand beds. And at the Ward's Island plant it is proposed to dispose of most, if not all, of the sludge by dumping at sea. Thus the fertilizer value of the recovered solids is no longer the reason for the choice of this process. This situation indicates that the sewage-disposal problem is still, in the main, the problem of disposal of the solids at the lowest cost. In past decades, one hope after another has been held out that materials of value could be recovered from sewage at a profit. Recovery of fertilizer with present knowledge, probably comes closer to breaking even than is possible by recovery of fuel value, recovery of grease or recovery of gas as commercial propositions, but so far the best showing has been made at Milwaukee, where in 1929 a profit of $1.50 was obtained per ton, based on operating cost and depreciation only, but, if interest and amortization were added, the net loss amounted to $11.75 per ton of dry sludge. Milwaukee was forced to go to fertilizer recovery by reason of the limited area available on the lake front.

The development and widespread use of separate sludge digestion, both of fresh solids and activated sludge, during the past five years, has been amazing. The main reason for this development has been the possibility of using the combustible gas produced during digestion of sewage solids for heating the sludge in the digestion tank, with consequent acceleration of the time required for digestion. Sludge in Imhoff tanks cannot be heated with success, since the open slot between the upper and lower compartments allows the escape of an excessive amount of heat by convection currents. In separate-digestion tanks, however, the only loss of heat is that due to radiation losses plus the heat units removed from the tank in the digested sludge or the supernatant liquor displaced when fresh solids are admitted. With this advantage, separate digestion has made it possible to utilize the heat value of sludge gas most efficiently.



Porous Plates for Air Diffusion, Special Flow Type, North Side Treatment Works

The gas given off from digesting sludge consists of approximately 75 per cent methane, 20 per cent carbon dioxide and 5 per cent nitrogen, with a heating value of 750 B.t.u. per cubic foot. This is considerably greater than the heating value of city gas, which averages about 530 B.t.u. per cubic foot. The production of sludge gas varies with the temperature and length of the digestion period, and also in accordance with the kind and amount of industrial wastes discharged into the sewers. If digestion is allowed to go to practical completion, the average gas production in the absence of industrial wastes amounts to about 0.4 to 0.6 cu.ft. per capita per day for settled solids, and from 0.6 to 0.8 cu.ft. per capita per day for both settled and activated sludge. The amount of gas produced from activated-sludge solids is only 66 to 75 per cent as much as produced from an equal dry weight of organic matter in settled solids.

Various proposals and attempts have been made to utilize sludge gas for sale to municipal gas companies, to produce power, or to heat the sludge in order to accelerate digestion. The latter use seems to be most promising, although the suggestion has been made that gas engines be used for compressing air for activated-sludge treatment, and that the exhaust gases and the cylinder-cooling water be used for heating the digestion tanks. The most common pro-

cedure is to heat water in gas-fired boilers and to pass it through coils suspended around the inner walls of the digestion tank. This method is used at most separate-digestion plants, although preheaters are used at some plants for initially heating sludge before it enters the digester.

Of the greatest importance is the temperature of digestion. Sludge removed from sewage is usually at about the same temperature as the sewage, which, in the northern part of the United States, varies from 40 to 70 deg. F. throughout the year, averaging about 55. Below 50 deg. F. gas production and digestion are very slow, requiring more than six months for completion. At 55 deg. F. approximately four months is required, at 75 two months, and at 85 about 40 days. Recently higher temperatures have been investigated, extending up to 130 deg. F., and it has been found that if the proper culture of thermophilic bacteria can be developed and maintained, the time of digestion may be cut down to five days or less.

The use of separate-digestion tanks has made scientific control of digestion more feasible than is possible with Imhoff tanks. A great deal of work has been done on the reaction of digesting sludge. The most valuable index of satisfactory digestion appears to be the pH value, which should remain above 7.0 for best results. If a sufficient quantity of well-ripened sludge is available, into which the daily accumulation of fresh solids is discharged, the reaction will remain alkaline and digestion will usually proceed without odors or foaming. If, however, there is no ripe sludge for seeding purposes, or fresh solids are fed too rapidly, an acid reaction occurs, with the pH dropping as low as 6.0 or even 5.5. Under such conditions it has been found advisable to add lime to maintain an alkaline reaction in the sludge.

Digested sludge must be dried to the point where it can be handled as a dry solid. This is accomplished on underdrained sand beds, or, in some cases, in glass-covered enclosures. The moisture content of the digested sludge as removed from the digestion tanks varies from 87 to 92 per cent. Such sludge can be pumped and flows as a viscous liquid. The sludge dries on sand beds to a moisture content of from 40 to 70 per cent, and is removed and disposed of as a waste product, or else is sold at a low price (50 cents per ton) or given away for local use as fertilizer. Such sludge contains from 1.5 to 2.0 per cent ammonia and 0.5 to 1.0 per cent P_2O_5, whereas mechanically-dried activated sludge may run up to 7 per cent ammonia and 4 per cent P_2O_5.

The sludge dried on sand beds was formerly removed by hand labor and loaded into dump-cars on a small industrial railway for disposal. Such procedure is still used for all but the largest plants, but in recent years several types of mechanical cleaners and loaders have been built by the Sanitary District of Chicago for use at the Calumet and the West Side Treatment Works.

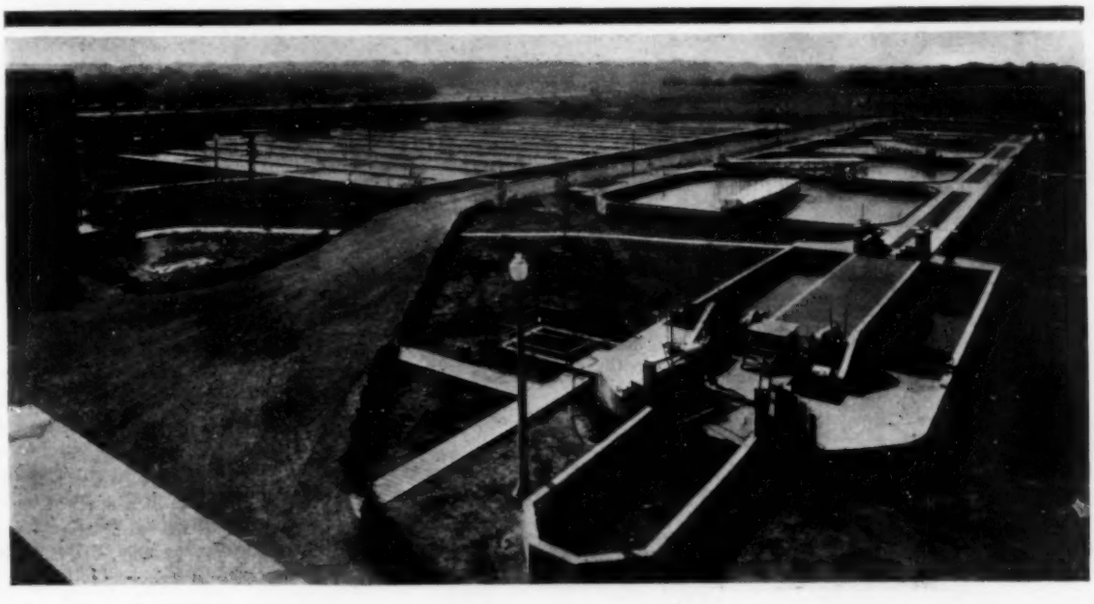
Open beds can be used only in summer. Rain and cold weather delay or prevent drying. In an attempt to increase the capacity of sand beds a large number of glass-covered beds have been installed in the past five years.

As it always has been the dewatering of sludge is still the major problem in sewage disposal. Full benefits of the accelerated digestion process are still unrealized because of the problem of drying the digested sludge. Even though it might be possible to digest sludge in five or ten days, if the sludge cannot be dried in winter it must be stored until spring. This is done at Peoria and Grand Rapids. Glass-covered beds are not a satisfactory solution of the problem of winter drying.

This situation has greatly stimulated the search for mechanical processes of drying which will be cheap enough to compete with sand beds. Vacuum filters can dry digested sludge to around 70 per cent moisture, but a rather large amount of coagulant must be added.

In the dewatering of sewage sludge, there seems to be some hope for a continuous centrifugal. This type of machine was tested at Milwaukee, and later at Baltimore, but the loss of solids in the effluent appeared to be an insurmountable obstacle, at least from the standpoint of cost. More recent consideration of the possibilities of developing a continuous centrifugal which will discharge a clear effluent and have a high capacity offers some hope for such apparatus. The nature of sewage sludge, either digested or fresh, is such that there is little hope of producing a cake or concentrate with less than 60 to 70 per cent moisture from digested sludge, or 75 to 85 per cent moisture from activated or fresh solids. The further drying of this material presents a difficult problem. Incineration offers a possibility worth consideration.

The goal toward which research is now being directed comprises: concentration of fresh solids before digestion, rapid digestion at high temperature, mechanical dewatering of digested sludge, and disposal of the digested sludge at the lowest possible cost. If all these steps could be put under mechanical control, sludge disposal would be greatly improved over present practice. The cost of such a series of mechanical operations is still far too great, but each step warrants careful study by all concerned. It is to be hoped that the next decade will witness even more progress than the past, toward the solution of the problem of the disposal of sludge, which is still the real problem in sewage disposal



Sewage Treatment Works, Peoria, Ill. Mechanically Cleaned Grit Chambers in Foreground. Preliminary-Settling Tanks at Right, Aeration Tanks at Left

Equipping Plants for Trade Waste Disposal

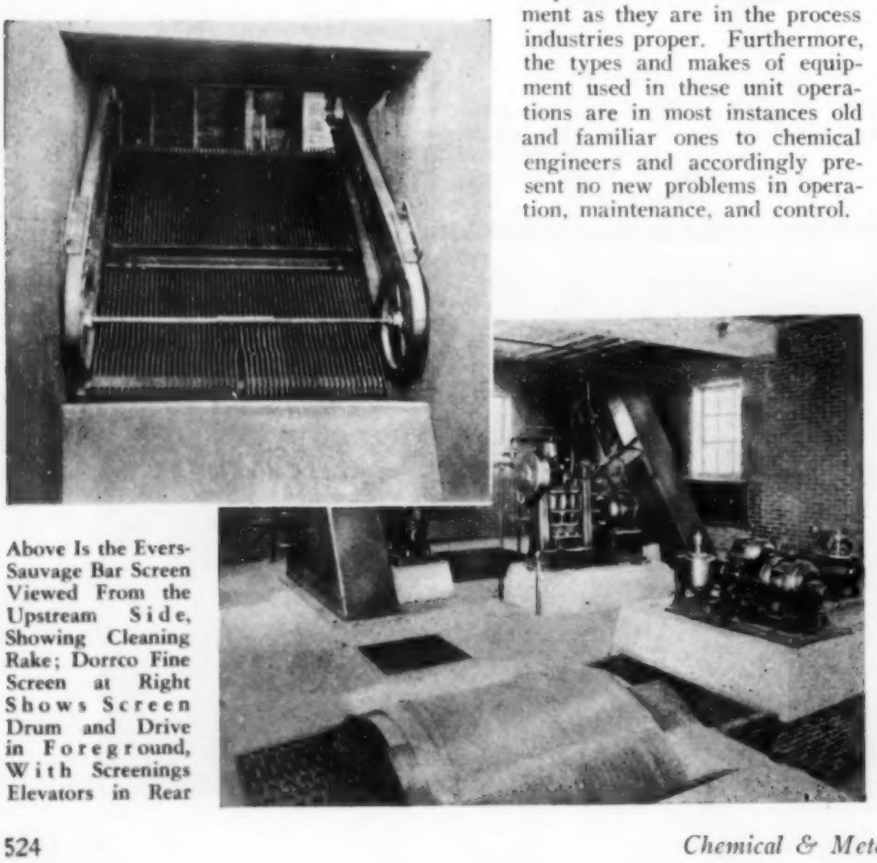
EDITORIAL STAFF REVIEW

IN THAT broad industrial grouping which has come to be known as the Process Industries it is particularly true that the foundations of continued success and of financial stability are built on research, technical development and the ability to see clearly today the needs and requirements of to-morrow. Those manufacturers who supply the process industries with their tools of production are motivated by the same pioneering spirit. They blend their specialized knowledge and experience with the outcome of research and development, thus engendering the machinery and technique which they contribute to industry. What at first glance may appear merely to be aggressive merchandizing becomes on closer analysis a high order of industrial pioneering: the creation and fostering of the desire for technical improvement and the satisfaction of these needs; and with these, the vision to prepare today for the future's requirements, even before they become clearly apparent to those in the user industries.

The manufacturer of equipment is closely allied in point of interest with the industries he serves, whose problems are frequently his, and whose state of prosperity affects his. If, to some extent, he has assisted in the solution of some of the difficulties of industry, then this link of common interest and mutual interdependence is immeasurably strengthened.

In reviewing the development of equipment used in the treatment of industrial wastes, it becomes at once apparent that trade waste treatment is a true example of chemical engineering, in that it may be broken down into a number of familiar, interconnected unit operations. Its unit operations of mechanical separation, mixing, chemical feeding, control, materials handling, evaporation and drying are as much a part of practice in trade waste treatment as they are in the process industries proper. Furthermore, the types and makes of equipment used in these unit operations are in most instances old and familiar ones to chemical engineers and accordingly present no new problems in operation, maintenance, and control.

¶No discussion of trade waste treatment and recovery would be complete without mention of the equipment on which so much depends for successful operation. The article that follows cannot hope to be exhaustive, but it can give at least a perspective which should be of value



Above Is the Evers-Sauvage Bar Screen Viewed From the Upstream Side, Showing Cleaning Rake; Dorrco Fine Screen at Right Shows Screen Drum and Drive in Foreground, With Screenings Elevators in Rear

Mechanical Separation

This phase of trade waste treatment may be subdivided into its four component parts: coarse screening, fine screening, sedimentation, and filtration.

Coarse Screening—If the industrial waste contains appreciable quantities of bulky solids such as sticks, rags, paper, fibrous or animal matter, then the first treatment step is coarse screening. Coarse screens may be divided into two types: manually cleaned rack screens and mechanically cleaned screens.

Plain bar screens are generally made locally and consist of a series of iron bars, spaced from ½ to 2½ in. apart, placed in the influent channel at an inclination of about 60 deg. Bulky solids are retained on the bars and are removed periodically by manual raking.

The mechanically cleaned bar screen made by the Dorr Co. has three principal parts: first, inclined bars of the conventional type; second, a motor-driven cleaning mechanism; and third, a float-operated control device. The cleaning mechanism terminates in a raking plate with fingers dove-tailing into the openings between bars. It operates on the pantograph principle with the driving parallelogram actuated by a stationary, inclosed, elliptically shaped rack and a motor-driven pinion on the moving part. As the raking plate clears the top of the bars, the accumulated screenings are discharged

by a scraper plate onto a drainage platform or conveyor belt. The motor switch is operated by a float control so that operation starts when the loss of head due to blinding of the screen reaches a predetermined maximum. It ceases when the removal of screenings restores the loss of head to the desired minimum.

Removal of screenings in the Evers-Sauvage mechanically cleaned bar screen is effected by a series of fingers, mounted upon a bar, and carried by two endless chains running on two sets of sprockets, one set submerged in the waste and the other set mounted at the top of the bars and driven by a motor and speed reducer. The submerged chains and sprockets are protected against the accumulation of solids by metal guards; and a draining floor or conveyor belt is provided for the collection of screenings.

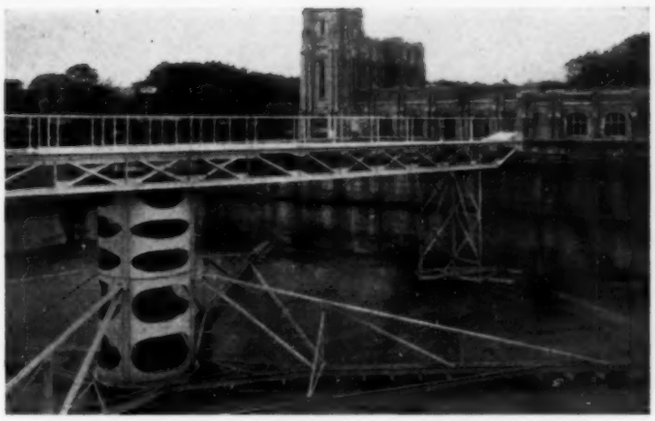
Inclined bars of the Link-Belt screen are cleaned by means of a carriage equipped with rakes which travels upward and downward over the screen on tracks. On the downstroke the rakes clear the bars, but on the upstroke the carriage travels on a track closer to the bars, between which the fingers of the rake then intermesh. Hoisting drums, driven by an automatically reversing motor and speed reducer, raise and lower the carriage by means of a steel cable.

Fine Screening—Fine screens are used in trade-waste treatment to remove floating solids prior to direct discharge of the waste to the sewer, or before more complete treatment.

The Bird screen consists of a cylindrical frame, covered with woven wire mesh, partially submerged in the channel and rotated on its horizontal axis by a motor and speed reducer. Solids form on the exterior and are sluiced off by water jets. The screened effluent passes off axially through an open end of the drum.

In the Dorrco screen unit, which is of the rotary, drum type, one end is closed and the other open for the discharge of screened waste. The solids are retained on the outside of the milled screen plates which form the drum and are carried through about one-half revolution before being discharged into the screenings pit by a counter draft of cascading water, produced by the rapid rotation of the drum. The screen cleans itself without the use of scrapers, brushes or jets of water. Screenings are removed from the pit by a bucket elevator.

The Reinsch-Wurl screen is a disk screen in which the perforated, rotating disk is inclined at an angle of about 15 deg. with the horizontal. It is installed in a concrete pit. As the screen slowly rotates, the screenings are carried above the level of the waste and into a zone where four brushes, which rotate at the top of the disk, sweep the screenings into a discharge spout.



100-Ft. Dorr Traction Clarifier in the Cedar Rapids (Iowa) City Water Treatment Plant; Note Oscillating Rake for Sweeping Corners of Tank

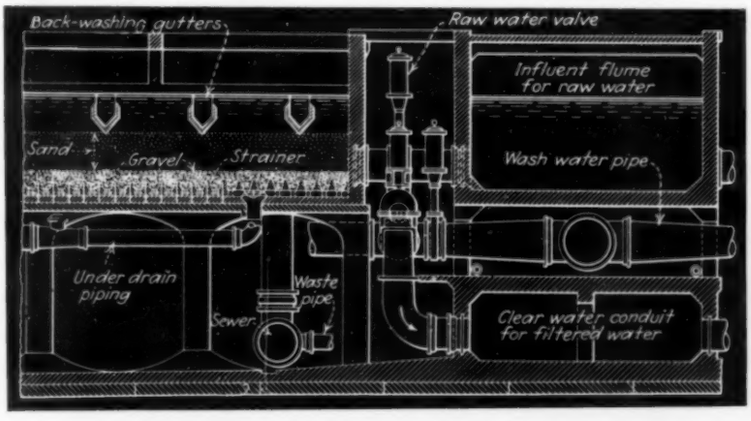
Sedimentation

Sedimentation is the practice of reducing the velocity of flow of an industrial waste sufficiently to allow the fine suspended solids to settle to the bottom of the vessel, leaving a clear supernatant solution. There are two general types of sedimentation tanks: first, plain tanks, cleaned manually and by sluicing, and intermittently operated; and second, continuous tanks in which the solids are continuously collected by some form of motor driven mechanism, swept to the discharge and are then removed by a pump.

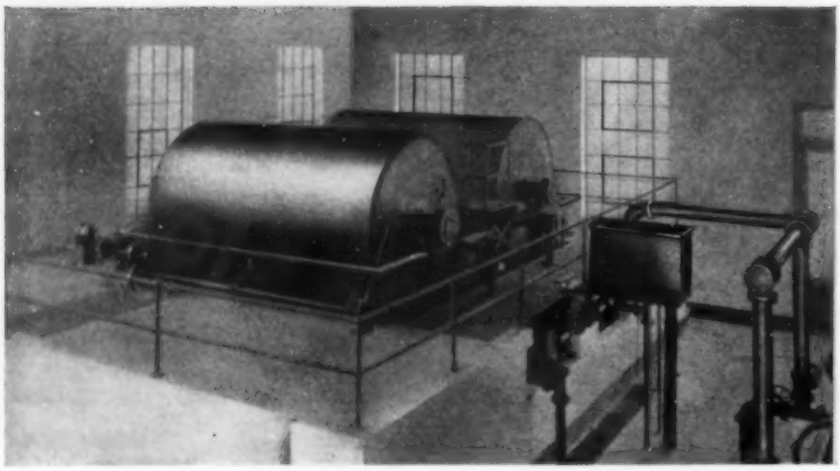
Dorr traction clarifiers are installed in square concrete tanks with submerged ports along one side for the introduction of the industrial waste and a weir on the side diametrically opposite for the overflow of the clarified solution. The clarifier differs from the thickener principally in the shape of the tank and in the method of feed and overflow. (A thickener uses a round tank, a center feed, and a peripheral discharge.) A slowly revolving mechanism is equipped with two sets of rakes, one of which sweeps the surface of the bottom in a circle inscribed within the square tank, and the other, an oscillating member, sweeps the tank corners. This raking mechanism is supported by and revolves on a central concrete pier and is driven at its outer end by a motor-driven carriage, running on a rail on the top of the tank. Collected solids are swept into an annular depression in the tank bottom which surrounds the central pier and are removed by a variable-stroke reciprocating pump. Construction of such a clarifier is shown above.

Link-Belt "collectors" are installed in rectangular concrete tanks, along one short side of which the waste is introduced through submerged ports. Along the other short side the clarified solution overflows. Settled solids are swept into a sludge hopper at the bottom of the tank at the influent end by collector blades which extend across the bottom of the tank and are carried by endless chains running on sprockets. The bottom of the tank slopes gently toward the sludge hopper, from which the solids are removed by a pump.

The Hardinge clarifier is installed in a cylindrical tank with feed entering through a semi-submerged well at the center and clarified solution overflowing across a circumferential weir at the tank sides, in the manner of a thickener. In certain cases feed is introduced and overflow removed through diametrically opposed segments. The settled solids are collected by a revolving spiral which sweeps the bottom of the tank and is driven by a motor-driven vertical shaft, supported on a truss bridging the top



Partial Cross-Section of a Typical Installation of Rapid Sand Filters in a Municipal Water Plant



Two Oliver Vacuum Filters Dewatering Municipal Sewage

of the tank. Sludge is pumped from a well-like depression in the center of the bottom of the tank.

Filtration

Filtration is employed either for obtaining a greater clarity of solution or a drier sludge than can be secured by sedimentation or screening alone. Filtration is generally preceded by screening or sedimentation. This operation may be classified according to its function as *clarifying* filtration, or as *dewatering* filtration.

Clarifying filters are of three general types: trickling filters, slow sand filters, and rapid sand filters. Trickling filters consist of an extensive bed of carefully sized mineral aggregate through which the waste is allowed to trickle slowly, giving up to the stone composing the bed colloidal and dissolved substances. These substances adhere to the surfaces through attraction and absorption, the dissolved organics being absorbed by the bacterial jelly which forms. Waste is sprayed intermittently upon the bed through nozzles and the treated effluent runs off through under-drains.

Slow sand filters, used for the removal of extremely finely divided suspensions, consist of square or rectangular beds filled with gravel and sand graded to a strict size specification. The bed is underdrained with tile. Waste is gently applied to the bed so as not to disturb the surface of sand, and during the initial filtration the effluent is throttled so that the waste may not pass through the clean bed at too rapid a rate. As solids accumulate, the rate of flow is correspondingly reduced and the throttling of the effluent may be relieved. When the filter becomes clogged with impurities it may be cleaned, either by flowing water over the surface or by scraping off the top layer to a depth of an inch or so. Rates of flow range from 2,500,000 to 8,000,000 gal. per acre per day.

Rapid sand filters are of two sorts, the pressure type, seldom used today, and the gravity type, which has now reached a high state of development. The essential features of rapid sand filters include: provision for chemical coagulation of the suspension with alum or other flocculants; and provision for completely cleaning the sand bed frequently by a counter draft of wash water. Chemical coagulation causes the formation of agglomerations of fairly large size which do not foul the bed as rapidly as finer particles. Furthermore, the frequent, sometimes hourly, purging of the bed by a counter flow of water results in high capacities for the gravity type ranging from 100,000,000 to 125,000,000 gal. per acre per day.

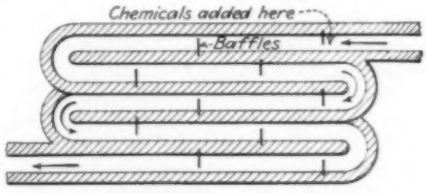
Filters used for dewatering the solid constituents of waste are of two general types: pressure filters, generally intermittently operated; and vacuum filters, usually operated continuously. The ordinary plate and frame press consists of a multiplicity of adjacent compartments formed by alternately placed corrugated or ribbed plates, layers of fabric, and metal frames, all clamped together under screw pressure. A common header feeds all compartments under pressure, each compartment having a separate outlet for filtrate. The assembly must be broken down for the removal of cake. A modification of this is the pressure shell filter, such as the Sweetland, Kelly, Burt and Vallez, in which filtration takes place on fabric-covered disks or surfaces supported within a shell containing wastes under pressure. Each surface has an individual filtrate outlet and the cake may, if desired, be sluiced out by water jets without opening the shell.

Continuous vacuum filters are of the rotary type with a portion of the surface submerged in the material being dewatered. Cake is formed and dried by vacuum, applied to each compartment in turn through a rotary port valve, and is discharged by scrapers, rollers, compressed air, or endless strings. The Oliver is of the drum type with the filter medium applied on the exterior and cake removed by a scraper, aided by compressed air. The Feinc differs from the Oliver only in that cake is removed on a series of endless strings which surround the drum and pass over an external roller. The Dorrco also is of the drum type, but differs in that the filtration medium is applied to the interior of the drum and the drum itself acts as a pulp container. Cake is discharged by a counter draft of pulsating air into an internal hopper which is evacuated by a chute or belt conveyor. The American's distinctive feature is the use of parallel disks, subdivided into removable sectors, as the surface on which the filter medium is applied. Cake is removed by scraper or by tapered, corrugated rollers, assisted by compressed air.

Mixing and Agitation

In waste-treatment practice the effluent frequently must be treated with chemicals or conditioning agents for neutralization, precipitation, or for coagulating the suspended solids into agglomerations of greater size. Mixing flumes and agitators of various types are used for this purpose.

Mixing flumes are simple channels of rectangular cross section fitted with staggered baffles extending from the sides so as to impart turbulence to the flow of wastes. In some cases the channel is in the form of a serpentine, doubling back on itself a number of times in order to get a long path of travel in a moderate space.



Serpentine Mixing Flume Equipped With Staggered Baffles to Promote Turbulent Flow

Paddle mixers vary widely in form. All have a central revolving shaft equipped with two or more vertical or horizontal arms. In certain cases turbulence is promoted by attaching baffles of various forms to the inner sides of the tank.

There are also such standard mixing devices as the Dorr impeller agitator and the Turbo-Mixer. The former consists of a large propeller, rotated by a vertical shaft which is driven by bevel gear and pinion from an overhead supporting structure spanning the tank. The propeller is inclosed within a draft tube which gives a strong upward current of water to supplement horizontal agitation with agitation in the vertical plane. Usually two or more of these agitators are used in series to minimize short-circuiting of the waste. A vertical partition between the draft tube and the tank sides is used to assure all ma-

terials passing at least once through the tube. Satisfactory mixing may be secured at solution velocities low enough not to destroy floc formations.

The Turbo-Mixer employs the centrifugal pump principle for providing agitation in both the horizontal and vertical planes. A high-speed impeller, centrally located in the tank, is surrounded by a ring containing deflector vanes. The liquid surrounding the rotating impeller enters near its center, is expelled tangentially, and is finally straightened out into a radial flow by the deflector blades. The rotating element is mounted on a vertical shaft which may be driven from a motor at the top of the tank or a motor directly below, the shaft in this case passing through a stuffing box in the tank bottom. The direction of flow in the tank is, first, axially upward and downward toward the center of the impeller, then radially outward to the side of the tank, and, finally, downward and inward in a circular path terminating in the axial draft at the tank center. A multiplicity of impellers and deflectors may be mounted on a single shaft where desired.

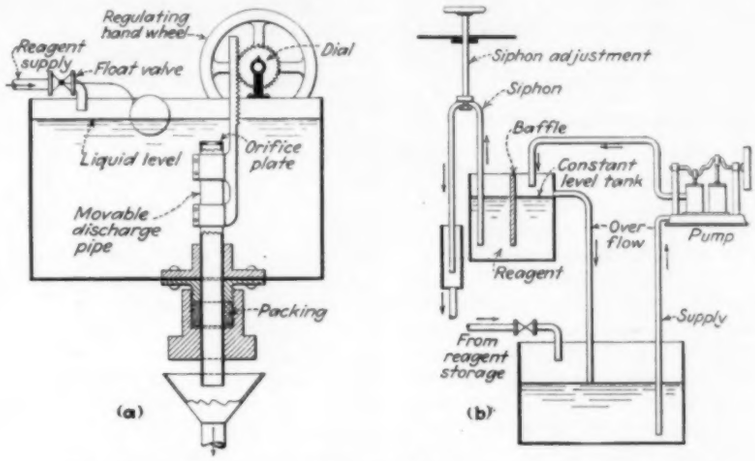
Reagent Feeding and Conditioning

Reagents used in waste treatment include both solutions and solids which generally must be fed continuously at a predetermined rate, and with extreme accuracy. The rates of flow of wastes frequently vary from day to day, as also do the chemical and physical composition of the wastes themselves. Accordingly, the devices used for feeding reagents must be flexible, accurate and easily adjusted to meet changing conditions.

Solutions such as alum, ferric chloride and dilute suspensions of milk of lime may be added and measured by orifice tanks, variable-stroke plunger pumps, adjustable weir boxes, and so on. The orifice tank is probably the simplest and is very widely employed. Solution is fed from a storage tank to a small constant-head tank, equipped with a float-operated ball cock for the maintenance of a constant liquid level. A vertical pipe, supplied at its upper end with an orifice plate, passes through a stuffing box in the bottom of the feed tank and may be raised and lowered by a handwheel. The latter is equipped with a dial to indicate the exact submergence of the orifice plate. Since the rate of flow through the orifice is a function of the head of solution above it, the dial on the elevating device may be calibrated for different rates of flow.

There are numerous types of plunger pump which, by means of adjustment, may be used for feeding purposes. In some cases the stroke is varied by adjusting the throw of the driving eccentric, while in others the speed of the pump itself is varied by driving it from a pawl and racket device or with a variable-speed drive.

The Sutra weir, manufactured by the L. M. Booth Co., is an ingenious constant-head feeding weir, the width of which is automatically varied in accordance with changes in the rate of flow or waste. This rate is measured by a float in a chamber connected to a second weir box which measures the flow of waste. The solution-feeding weir is of the adjustable-flow type, the head being constant and the rate of flow proportional to the width; but the waste-measuring weir is of the proportional-flow type, the rate of flow being directly proportional to the head.



Feeding Devices for Liquids: *(a)* Sectional View of Adjustable Orifice Feed Tank; *(b)* Schematic Diagram of Constant-Level Tank With Adjustable Siphon

Solids such as burned or hydrated lime and soda ash may be measured and fed by a number of different types of weightometer belts, variable-speed screw feeders and adjustable-cut, rotating table feeders.

Weightometer belts consist of a short constant-speed belt conveyor, one section of which passes over a set of floating idler rollers connected to a scale beam. A feed hopper equipped with an adjustable gate feeds material upon the moving belt. The opening of the gate is so controlled by the scale, and hence by the weight on the belt, that the feeding rate is maintained constant at any desired magnitude. Such devices are usually accurate within less than 1 per cent and, once set to deliver a given poundage or tonnage per day, will maintain it by constant correction.

Screw feeders are made up of a feed hopper, an inclosed screw conveyor passing through the bottom of the hopper, and a belt or motor-driven set of pawls, engaging a ratchet wheel on the screw shaft. An adjustable shield surrounding the ratchet wheel determines the peripheral distance, measured in ratchet teeth, through which the screw will be rotated by the moving pawls at each revolution of the drive shaft. Although not self-regulating like the weightometer, it may be adjusted and easily calibrated and is sufficiently accurate for most waste treatment conditions.

Two Dorr Impeller Agitators Installed in Square Concrete Tanks in a Sewage Treatment Plant

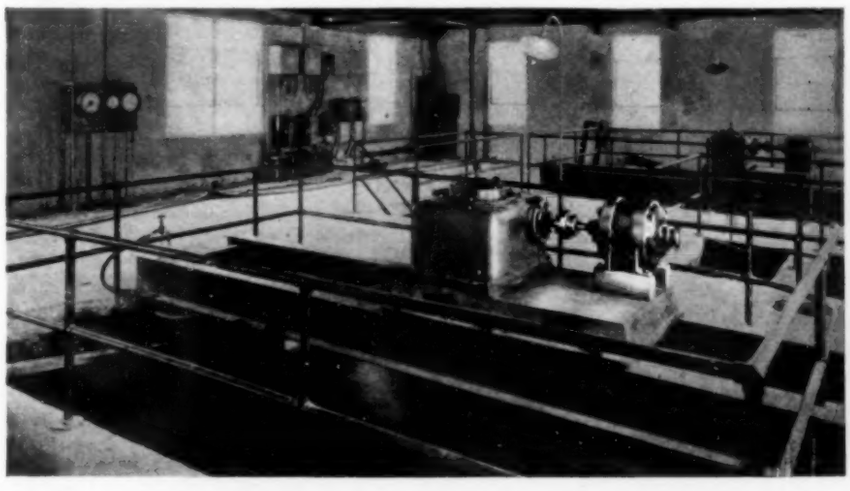


Table feeders consist of a feed hopper terminating in a vertical cylindrical spout, feeding, directly onto the center of a revolving, circular, horizontal table. The material builds up in the form of a truncated cone according to its angle of repose. As it is revolved on the table, an edge section is continuously sliced off into a feeding chute by an adjustable scraping blade which moves radially across the face of the table. Adjustment is made in two ways: first, by a vertically adjustable collar on the end of the cylindrical spout which varies the depth of material on the table; and second, by the adjustable knife which determines the width of ring sliced off at each revolution.

Measurement and Control

Aside from reagent feeding, which has already been considered, regulation of hydrogen-ion concentration, and sometimes of electrical conductivity, are generally the only factors requiring accurate control in trade-waste treatment. In those instances where the disposal involves the manufacture of a salable byproduct, control of temperature, pressure, flow, or other functions may become imperative, but where nothing of value is recovered, it is necessary, of course, to effect disposal as cheaply as possible. This usually will require rather simple treatment in which not many of the process variables need be held within close limits.

In disposing of dry or semi-dry, insoluble solid wastes no control or record, other than perhaps weight of the material, will ordinarily be required. For recording the weight of waste solids, various sorts of scales, ranging from simple hand-operated platform scales to integrating conveying scales may be used, depending on the quantity that must be handled. Liquid wastes and suspensions will frequently require chemical treatment of some sort, such as neutralization or coagulation. Control of pH is desirable in every case where a coagulant such as alum is used to assist sedimentation or filtration.

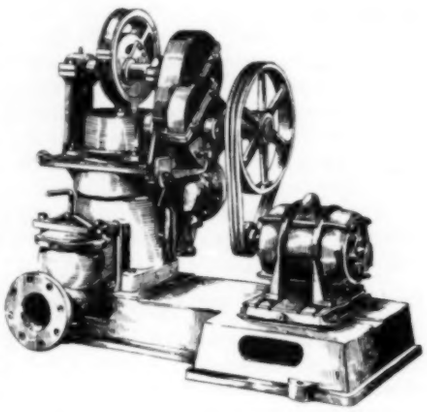
Ordinarily this can be accomplished by periodic determinations of pH, using colorimetric or electrometric means. The former is the more general because of the low cost of the apparatus and its ease of use. Colorimetric pH outfits consist of suitable indicator and buffer solutions which are added to a known quantity of the sample to give a color dependent on the pH. This color is then compared with a series of liquid or glass color standards. The electrometric apparatus consists of an electrolytic cell containing the sample which generates an emf. dependent on the pH. This is measured with a millivoltmeter. The cell makes use of two special electrodes, a calomel electrode of constant potential, and a hydrogen or quinhydrone electrode, the potential of which depends on the pH.

The electrometric method has the advantages of elimination of the human equation, non-dependence on color, and possibility of recording and/or automatic controlling. Cells for continuous pH measurement have been devised and are in satisfactory operation, although the complexities of continuous measurement and control are still far from solved in certain cases. Recording and controlling instruments used have been the automatically balanced potentiometers made by the Leeds & Northrup Co.

Instead of measuring pH, electrical conductivity sometimes is used advantageously in the case of electrolytes. The method is applicable only where each concentration, acidity, or alkalinity is characterized by a definite conductivity at a given temperature. Leeds & Northrup Co. has developed an alternating-current bridge in one arm of which a conductivity cell immersed in the test liquid is placed. By using an automatically balanced circuit controlled by an a.c. galvanometer this device will record and/or control.

It is also desirable at times to know the flow of the waste liquid. For this purpose indicating, recording, and/or totalizing flowmeters of the orifice, Venturi, or weir types are generally used.

Instrument applications in the case of waste gases may include analysis, both manual and automatic, and the use of dust, fume, and smoke detectors or recorders. Among the means of analysis, the ordinary manually operated Orsat, and automatic recording Orsats of the Hays type are often used; for example in the CO_2 analysis of flue gas. Thermal-conductivity gas analyzers are being used increasingly in this and other services. Smoke, fume, and dust recorders depend on the interruption of a beam of light or of heat rays. In such instruments the detecting element is a photoelectric cell or a thermopile. Recording and signaling models are now available commercially. The principal difficulty in their use lies in the provision of adequate means for keeping clean the glass surfaces through which the light beam or heat rays must pass.



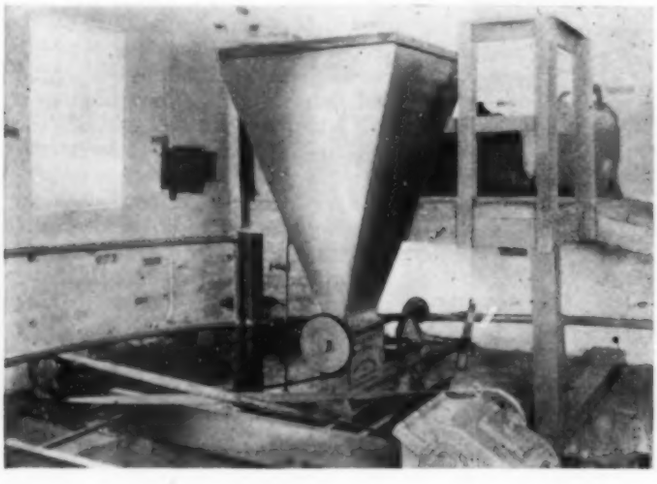
Barnes Single Cylinder, Adjustable-Stroke Plunger Pump for Handling Heavy Sludges

Materials Handling

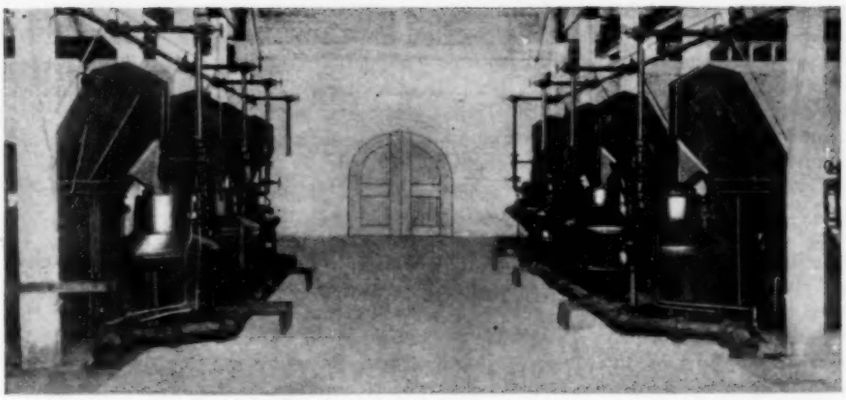
Materials-handling problems in waste treatment are not generally difficult ones. The materials dealt with may be classified as solutions, dry solids, and sludges or pulps. Equipment used in other lines of industrial processing are used here satisfactorily.

Non-corrosive solutions may be handled in any one of the conventional types of piston or centrifugal pumps. Where corrosive conditions prevail, the transfer of solution is generally effected by the use of special alloy or Duriron plunger pumps; alloy, Duriron, stoneware or rubber-lined-steel centrifugal pumps; or corrosion-resisting air-lift columns, and blow cases of the montejus type. Liquid-handling equipment of this type finds an application not only in dealing with raw wastes but also with the corrosive solutions used for waste treatment.

Sludges may best be handled in special types of plunger pumps, diaphragm pumps, and pneumatic ejectors. The Barnes plunger sludge pump is widely used for handling non-corrosive sludge and is capable of discharging against pressure heads of 50 lb. pressure. The plunger cylinder is driven by an adjustable eccentric and is equipped at its lower end with an "agitator plate" which effectively prevents the accumu-



Gauntt Lime Feeder Installed Over Paddle Agitator, Handling Quicklime for Pretreatment of Textile Wastes



Battery of Eight "Pneumatic Ejectors" Handling Screenings From Bucket Elevators

lation of segregated solids in the body of the pump. Intake and discharge valves are of the easily seating ball type and the entire unit, complete with driving motor, is mounted on a substantial baseplate.

Where extremely heavy or corrosive sludges are handled, the Dorrco diaphragm pump is often used. This pump has an adjustable stroke, ball valves, and direct motor drive; but it differs from the Barnes in that an oscillating rubber diaphragm is the working element and the entire pump may be rubber-lined or constructed of special alloys for corrosion-resisting duty. The suction type will effect lifts corresponding to 14 ft. of water, while the pressure type will deliver against heads corresponding to 50 ft. of water.

A convenient pneumatic method for handling wet screenings and fibrous sludges is in the special device developed by the Pneumatic Ejector Co. A conical receptacle is provided with pneumatically operated gates on the cover and in the bottom discharge pipe, and with an air line leading to its interior for ejecting the contents. The throw of a lever, or pressure, on a button, closes the discharge gate and opens the feed gate, preparing the ejector for receiving its charge. An opposite throw of the control lever, or pressure on another button, closes the feed gate, opens the discharge gate, and introduces compressed air which rapidly evacuates the contents through the discharge line leading from the bottom of the cone.

Dry solids, such as lime, alum and soda ash, may be handled in any one of the common ways generally employed in industry. Bucket elevators, conveyor belts, spiral and flight conveyors may all be used in their proper place, without special consideration as regards waste treatment practice being given their selection and use.

Where the quantities handled are large and the dust nuisance is a factor, some type of pneumatic conveying system may be used for transferring the reagent from the car as it is received, directly to the storage bins in a single operation. Such a system requires an exhauster or blower, a flexible conveying line with intake nozzle, and a special receiving hopper and air filters. The system usually works very much like an ordinary, household vacuum cleaner. In the most common form the pump applies vacuum to the receiving hopper, the nozzle on the end of the conveying line is inserted in the material, the inrush of air carries the material through the line and into the hopper, and the air leaves the hopper through filters. The material drops to to the bottom of the hopper and is discharged through a rotary air lock into the storage bins below.

Drying

In order to facilitate its eventual disposal, solid matter contained in industrial wastes must generally be dried, after it has been concentrated and separated from the greater part of its associated water or other liquid. The selection either of solar drying or artificial drying will be determined by the volume and the possible value of the solids, by the space available and the degree to which the presence or absence of disagreeable odors is a factor.

Solar Drying—Probably the simplest and cheapest method of drying sludge from waste-treatment plants is that of lagooning on a tract of land of considerable extent, surrounded by a cheap wall or earthen embankment a foot or more high. The wet sludge becomes concentrated slowly by solar evaporation, but even after several months it is far from dry. Where offensive odors and general unsightliness are not factors of importance, lagooning is quite extensively used.

An improved solar method of drying is the use of under-drained sand beds. Such sludge-drying beds consist of a system of under-draining tile pipes, covered by layers of crushed stone and gravel, and finally sand. They are divided into smaller areas by concrete or wood partitions. Part of the liquid drains into the soil and part evaporates. The sludge is applied in a thin layer and, under good conditions of a porous soil and abundant sunlight, will dry out quite completely in two weeks to a month.

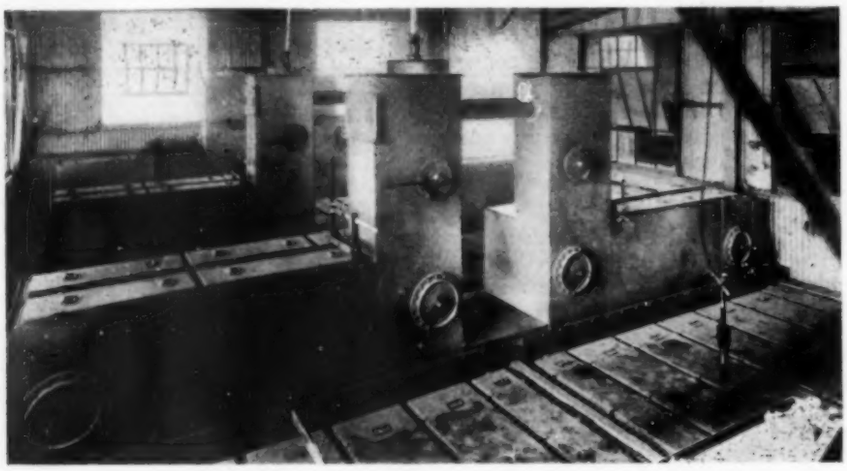
Artificial Drying — Filtration, preferably continuous vacuum filtration, generally precedes the artificial drying of solids from a waste-treatment plant, in accordance with general principle of chemical engineering that as much liquid as possible be removed by mechanical methods before applying the more expensive thermal method. It is true that few waste-treatment plants can justify the inclusion of artificial sludge drying, for only when the dried product is readily merchantable is expensive secondary treatment of this nature economically attractive.

The tunnel dryer, as its name implies, is a tunnel through which the product to be dried is conveyed continuously or intermittently on tray-loaded cars. The products of combustion or heated air from a coal, oil or gas-fired furnace are drawn through the tunnel by a motor-driven fan, countercurrent to the motion of the cars. Low first cost of this method is counterbalanced by high fuel consumption as the sludge in the pans tends to cake at the surface which retards the evaporation of liquid in the interior.

Rotary shell dryers of several types have been used. All are similar to the extent of having externally located fur-

Sludge-Drying Beds, One Filled and One Ready for Filling

naces and revolving cylindrical shells, slightly inclined to cause the waste solids to flow through them in an axial direction. In the direct type, the products of combustion come in direct contact with the solids; in the indirect type the products of combustion usually pass through an inner circular tube and evaporate the moisture by heat conducted through the tube wall. In the direct-indirect type, the products of combustion make two passages through the dryer, one through the inner, indirect-heating tube and the other through the dryer shell itself, in direct contact with the solids. A modification of the shell dryer is used in the packing house industry. The cylindrical, slightly inclined shell is stationary and the solids contained therein are continuously mixed and kept moving by paddles attached to and rotating with a shaft passing axially through the shell.



Top of Cottrell Precipitators Used for the Recovery of Dust From Cement Kilns

The spray dryer has been used in at least one waste-recovery problem, for drying tin-bearing wastes from textile weighting and dyeing plants. The sludge is atomized by a high-speed disk, revolving at the top of a chamber through which pre-heated air is forced. Instantaneous evaporation takes place and the finely divided product is collected in the base of the chamber and discharged by a chute to containers below.

Preventing Atmospheric Pollution

Strictly from an engineering viewpoint, the prevention of atmospheric pollution has little in common with the pollution of streams and rivers with water-borne industrial wastes. A brief discussion of the equipment used for treating dusts, sprays and fumes may, however, not be out of place in this at this point, since a company is frequently urged by the same regulatory officials to consider both stream and air pollution jointly as component, related parts of a general project for waste treatment.

Sources of atmospheric pollution may broadly be grouped in two classes, mechanical dispersoids, such as dusts and sprays, and condensed dispersoids, such as fumes and mists. Five types of equipment may be used for the treatment of these sources of pollution, including: settling chambers, utilizing the gravitational principle; cyclones and baffled boxes, operating through inertia; bag houses (the filter principle); wet scrubbers, actuated by water sprays; and finally electrical precipitators, based upon electrostatic induction.

Settling chambers are generally designed and built by the user and have such dimensions as to give the smallest particle which it is desired to remove time to settle out of the streams of air or gas. Previous obstructions such as chains and wire curtains are effective in minimizing eddies. The settling chamber is useful only for the removal of dusts and sprays.

Cyclones and baffle chambers depend upon centrifugal force for the separation of the dispersoids from the gas. In the ordinary cyclone collector, the gas enters tangentially and generally makes two complete revolutions before passing out through an outlet in the top. The cyclone has the conventional conical form and is constructed of sheet metal. Collected dust is discharged through the apex of the inverted cone. In a recently developed form (the Multi-Clone) a number of cyclones, of relatively smaller diameter in proportion to their length than is usual, are used in parallel with a considerable increase in collecting efficiency. In the baffle type dust chamber, high gas velocities and small radii of curvature of the gas streams are employed. A common form is the so-called "zigzag" baffle chamber used for the separation of dusts and sprays.

Bag houses and stocking collectors are essentially gas filters, and are very effective in the removal of dust. They consist generally of a multiplicity of cylindrical tubes of cloth, suspended from their closed upper ends and with their open, lower ends connected to a gas inlet header which also serves as a hopper for the collection of dust. Some stocking collectors are arranged for entrance of the dust at the top of the tubes, and discharge alone at the bottom. Periodically the bags are shaken by manual or mechanical methods; and at less frequent intervals the dust thus shaken down into the hopper at the bottom is removed.

Wet gas scrubbers are of various forms and types. In general they operate on the principle of causing the gas to pass through fine sprays of water or to impinge on baffles and other surfaces which are constantly kept wet. In the ordinary locally built spray tower, the gas to be cleaned passes upward through a series of baffles, grids or other obstructions which are continuously wetted by water that is sprayed at the top of the tower so as to cascade downward to an outlet in the base. A more effective type of scrubber is the mechanical washer. Here the feature is a mechanical dispersion of the spray water in the path of the gas. Passing upward through the cylindrical shell of the washer, the gas is forced to follow a path which passes through a number of these mechanically dispersed sprays. Frequently all of the water is supplied in the topmost dispersion chamber and is collected and successively re-used in each of the lower dispersion chambers as it gravitates to its outlet in the bottom.

In the Cottrell electrical precipitation method, a uni-directional electrical difference of potential is maintained, and a current set up between two electrodes insulated from each other, between which the gas is passed. Due to the high electrical field, the ions formed through ionization of the gas by molecular collision near the discharge electrode are carried through the gas to the collecting electrodes at extremely high velocities. Particles in the gas stream, both liquid and solid, attach themselves to these rapidly moving ions and are carried with them to the collecting electrodes.

Cottrell precipitators are of two types, the plate type where the fundamental unit is the gas duct between two parallel plates, screens, rows of rods, etc.; and the pipe type, where the unit is a pipe of any convenient cross-sectional shape. The plates, screens, pipes, and so on, are the collecting electrodes, while the discharge electrode in each case is a wire or sharp edge located midway between the collecting electrodes or in the center of the pipe. The apparatus for producing the high-tension electrical field consists of a transformer for stepping up the line voltage to 50,000—75,000 volts, a suitable rectifier for changing this current from alternating to direct, and the necessary switchboard and regulating instruments. The collection efficiency of an electrical precipitator is a function of time and the economic limit generally lies between 90 and 99.9 per cent.

CHEMICALS, regarded as a community factor, may be justly considered an "antitoxin" to manufacture. While capable of being themselves a source of grievance, they nevertheless constitute the most useful medicine not only against their own industry's objectionable aura but also against other community wastes of any description. Their action is multifarious: it may be mere chemical neutralization, or the precipitation and removal of sludges, or again the provision of a medium for enabling microorganisms to make the final disposal. Some of these chemicals were beneficently at work long before chemical action was at all understood, but a surprising number have been only recently developed and applied. To instruct the chemical engineer in their action, the following symposium has been prepared.

Sewage and Trade Waste Problems Solved by Chlorine

By
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ALL MODERN sewage or industrial waste-treatment processes are designed to relieve these wastes of their offensive nature. Ordinary sedimentation or chemical precipitation is frequently sufficient. Where necessary, these simple, inexpensive processes are supplemented by oxidation and stabilization of the supernatant leaving the settling tanks. The kind and extent of the treatment also depend on dilution afforded by the waterway receiving the effluent. It is frequently necessary to disinfect these effluents.

In addition to its use as a destroyer of disease- and nuisance-producing organisms, chlorine is now applied for other purposes in connection with sewage and waste-treatment processes. Experiments and numerous practical applications show that a relatively small chlorine dosage added to sewages prior to any treatment delays septicity and the formation of hydrogen sulphide and thus prevents odor nuisance from sewage and sewage-treatment plants. Furthermore, should hydrogen sulphide be already present in the sewage at any stage of its history, chlorine destroys it instantly and completely. Since the destruction of masonry sewers and other structures has been traced to attack by sulphuric acid, formed by oxidation of hydrogen sulphide produced in sewage by bacterial action, the application of chlorine to sewers and at sewage plants secures them against attack and disintegration.

Of considerable and increasing importance is the effect of chlorination on the putrefaction of organic wastes in general. Solids which would otherwise float or settle out in waterways having been removed, the non-settleable, putrescible matters are rendered less putrescible by chlorine, and thereby the depletion of oxygen in the waterways is materially lessened. By its sterilization effect chlorine retards biological activity; consequently the rate of oxygen depletion by the bacteria feeding on organic matters is so diminished as to allow greater dilution and re-aeration to take effect before normal conditions are re-established. The oxygen balance is maintained at a higher level, and as a result foul conditions in the waterway are prevented. This is of value in tidal waters where the ebb and flow of the tide supply dilution and effect dispersion. The result is highly valuable in situations where the waterway is normally deficient but enters a larger waterway after several hours of flow. This particular effect may be likened to that which is observed during winter when biological activity is at its low ebb.

In addition to the retarding effect the production of less or possibly non-putrescible compounds from the more rapidly putrescible materials which chemically combine with chlorine will produce an actual reduction of oxygen required. In this way the five-day oxygen requirement of the settled sewage or industrial waste is reduced as much as 25 to 40 per cent, depending upon the composition of the effluent.

Chemical precipitation employed in conjunction with chlorine offers an even greater effect in reducing stream loading than may be secured by ordinary sedimentation and chlorination. The combination is extremely flexible, with the added advantages of economy of operation, compactness of plant, and low investment cost and depreciation. A good illustration of this type of treatment is found in that recently developed for meat-packing waste treatment as described elsewhere in this issue.

Biological growths in general are eliminated by chlorination. Among the newer uses for chlorine in this connection is that for elimination of the "slime" growths that (1) occur in paper mills and interfere with the making of paper products and create economic losses; (2) cause loss of efficiency in power generation by coating the water side of the tubes in steam condensers and cooling coils generally; (3) create unsightly appearances in streams and choke the distributors and biological filter beds at sewage and industrial waste-treatment works.

In the activated sludge process of sewage treatment, proper biological conditions are essential. The appearance of filamentous bacteria or fungoid growths upsets the process. To control such conditions chlorine is helpful when applied to the incoming sewage and also at times to the activated sludge returned to the influent sewage for the purpose of "planting" in it the flora and fauna. And chlorine and chlorine compounds are useful for cleaning sewers and pipe lines of biological growths which frequently create undue loss of head and decreased carrying capacity.

In the digestion of sewage solids, acid production or "foaming" sometimes creates difficulties. Application of chlorine to the crude sewage appears to be a helpful measure. Solids separating from excessively chlorinated sewage, when mixed with digesting sludge, strengely enough, digest more rapidly and with less undesirable acid production than otherwise. Prechlorination of sewage ahead of settling tanks is assuming importance for many reasons, and where practiced does not appear to

hinder biological actions later involved in the several treatment processes now in general use. On the other hand, biological functions are frequently improved.

Perhaps the oldest application of chlorine in industrial waste treatment is that of tannery waste disinfection in which case it has been proven the most practical and economical agent for destroying anthrax and other germs. Since it has been amply demonstrated that chlorine absorbed renders organic wastes in general less putrescible, and further, in view of the extraordinarily high chlorine absorption by tanning plant wastes, it may safely be assumed that reduction of the oxygen demand of such wastes is considerable.

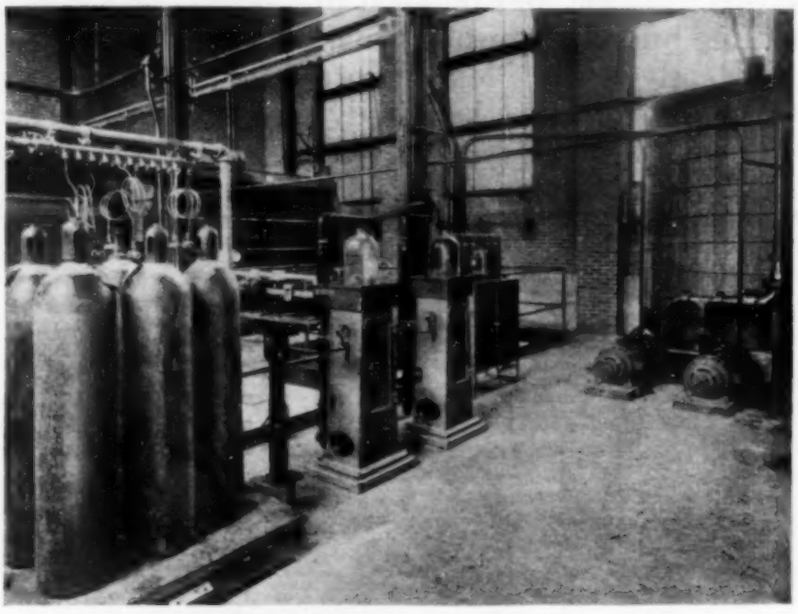
Chemical precipitation with chlorination is being effectively employed as an economical and effective process in canning waste treatment. The chlorination reduces appreciably the residual oxygen demand in the effluent from the precipitation tanks and is an aid in preventing nuisance in the receiving stream. The prevention of septic stream conditions with unsightliness and foul odors and the elimination of slime growths from the stream beds are provided by chlorination. The short seasonal run of canning plants makes the precipitation-chlorination process attractive economically and practically.

Chlorine is applied to stabilize creamery wastes without previous treatment having been given. The primary result is that of retardation of septization and odor production while the effluent is being employed in irrigation. In other instances creamery wastes are being stabilized by chlorine application in sufficient dosage to retard septization in small streams for short distance of travel before entering amply large streams. Chemical precipitation of creamery wastes is practiced at a few points, and where necessary the process may be aided by chlorination.

In Australia a method of treating wool scouring wastes with chlorine has been developed. The prime purpose is to obtain lanolin of a high grade. The waste is made alkaline and settled. Chlorine is thereafter applied through a recirculating pump and liberates the greases from the protective albuminous colloids and soaps. Nascent oxygen and carbon dioxide evolved cause the fats to separate to the suface of the waste which is made acid by chlorine. The foam is accumulated in holding tanks for subsequent heating and filter pressing.

In America chlorine has to date been contemplated only as an aid in reducing stream pollution by beet-sugar factory wastes. Abroad, however, because of low stream flow and deficiency of water supply, the wastes are treated with lime, settled and the precipitation basin effluent is chlorinated. As much as practicable of the chlorinated waste water is returned to the mill for reuse in certain parts of the manufacturing process, and thus stream pollution is curtailed.

Reference has already been made to chlorination in paper and allied products manufacture for the elimination of slime which interferes with production and economy of manufacture. It is desirable if possible to return white water to the mill and thereby at one time reduce fresh water consumption and recover valuable "make-up" materials, including stock, which otherwise go to the sewer in the form of white water. By re-use of white water, reduction of stream pollution also results. Progress is being made in this matter, and chlorine is applied to the returned white water in order to prevent the troublesome slime formation which in the past has been a serious obstacle to adopting the closed or partially closed system in paper mills. This subject is treated in more detail elsewhere.

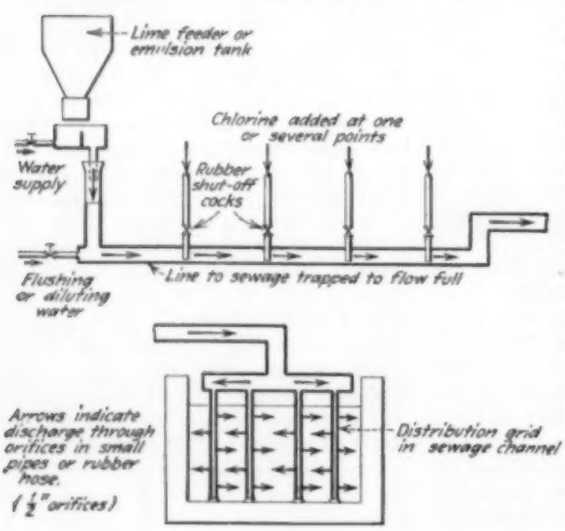


Desliming Equipment for Condenser Water

In water chlorination, ammonia application ahead of the chlorine has served to increase the efficacy of chlorination, as it causes the disinfecting action of the chlorine to become much more persistent, due to the production of chloramines. In treatment of paper-mill waters ammoniation has also increased the efficacy of the process and seems likely to prove particularly valuable in chlorination of white waters. In sewage chlorination it is not necessary to add ammonia, because of its natural presence in the sewage. A recent development incorporates the application of alkali along with the chlorine, and this procedure has proved quite helpful in increasing the efficacy of chlorination. Chloramines are more readily produced from alkalinized chlorine, and less chlorine is required to satisfy the demand of the sewage or waste. The residual chlorine secured is more permanent and the observed effects indicate that the production of chloramines accounts for the improved results secured.

The cheapest alkali at present is lime; therefore it is now being used as the chlorine carrier; hence the name "Lime-Chlorine Process." In this process, which was developed by the writer, the calcium hypochlorite is produced in the lime-chlorine mixture while en route to the point of application. In practice a

Arrangement Used in Lime-Chlorine Process

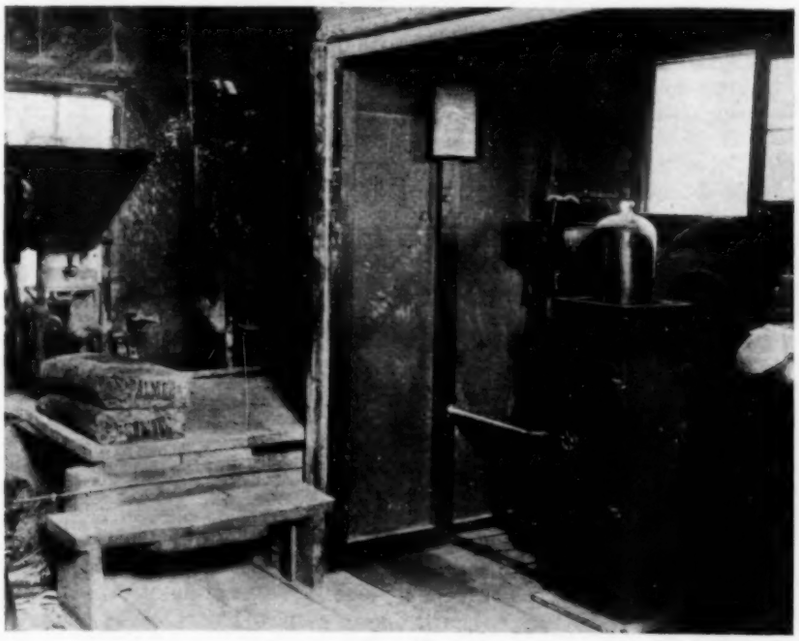

Lime feeder or emulsion tank
Chlorine added at one or several points
Water supply
Rubber shut-off cocks
Flushing or diluting water
Line to sewage trapped to flow full
Arrows indicate discharge through orifices in small pipes or rubber hose. (½" orifices)
Distribution grid in sewage channel

dry-feed machine is used to feed hydrated lime at a continuous rate. The lime is carried in aqueous suspension through a pipe line into which is delivered the discharge from an ordinary chlorinator or other apparatus used for measuring the chlorine gas. The reaction between the lime and chlorine is practically instantaneous, and only a short travel through the pipe line is required prior to discharge of the alkaline hypochlorite solution to the sewage or waste. A slight excess of lime is carried, as indicated by a test with phenolphthalein which should produce a flash of pink before the bleaching effect discharges the color and serves as the control test employed in regulating and checking the lime dosage. Usually the ratio found requisite is 1.25 lb. or somewhat less, hydrated lime to each pound of chlorine applied. The reduced chlorine requirement more than offsets the cost of the lime involved, thus rendering the process attractive economically as well as otherwise. The first practical installation was that at the Baltimore, Md., sewage works where 60,000,000 gal. of sewage are treated per day.

Bleaching powder and solid and liquid hypochlorites have their measure of usefulness in some of these fields also. Their use is predicated upon local conditions and economic considerations as well.

Briefly, long experimentation and practical applications have proved new, valuable, and highly interesting applications of chlorine. It is not a "cure-all." It does not replace sewage plants. It is a case of each tub on its own bottom. It is also interesting to note that chlorine has displaced no other chemical in these applications and has therefore not added to the highly destructive competition among materials susceptible of the same uses.

Lime and Chlorine Are Used in Treating Industrial Wastes



suspended or dissolved matter precipitates quickly and can then be separated in clarifiers or sedimentation tanks. Tannery and paper mill wastes occasionally need lime for alkalinity. In the first case the lime acts both as a precipitating agent for sludge and for producing an alkaline medium for the final purification. In paper-mill wastes ferric chloride is added with the lime to form a flocculent precipitate dragging down the coloring matter. Sulphite liquors treated with lime are first settled out and then cascaded to remove the sulphur dioxide gas.

Sugar Refinery Wastes

Lime has been applied in treating the wastes of both cane and beet sugar refineries. In the former case, the effluents, especially the press water, are treated and aerated until the reaction is alkaline and then are decanted and filtered. The beet sugar washing water, a comparatively mild waste, is also cleaned by precipitation with lime.

Food industries seem to require lime treatment of effluents fairly generally. Examples are the tomato cannery, dairy, and sugar factories (already mentioned). Here again it is a simple matter of neutralization and coagulation.

An interesting new use for lime has been recently developed in the "lime-chlorine" process, reported in this issue by L. H. Enslow. Since it is discussed at length there, it will suffice to mention the principle that chlorine as an active disinfectant is applied under better control when first mixed with lime to form calcium hypochlorite. In this case lime plays an altogether different rôle from those in the cases already indicated, acting wholly as a check on the chlorine application, which otherwise would require careful attention, with a lower chance of efficiency. In the production of hypochlorite, incidentally, the lime slurry first produced can, of course, be partly diverted to other uses in the same plant.

Using Lime to Adjust Acid Value of Sludge

AS might be expected, the rather strongly alkaline characteristics of lime were its original recommendation as a useful material in the treatment of polluted liquids. In fact, until comparatively recently its application to waste treatment was confined chiefly to maintenance of a desired acid-alkali ratio in specific phases of the treatment.

A lime treatment is found necessary in adjusting the pH value of certain sewage sludges prior to subjecting them to biological reaction. Again, in the precipitation of carbonate, a slight excess of lime is necessary to insure the formation of neutral carbonate, which is insoluble in the cold.

Cases where the use of lime has assisted in the disposal of chemical waste have been reported rather numerously in the last three years; therefore, a brief survey of the various principles involved will suffice at this point. These have been summarized also in a paper entitled "Lime in the Treatment of Trade Wastes," by R. H. Ferguson, published under a fellowship at Ohio State University.

Acid wastes flowing from steel mills require simple neutralization; the same is true in water-gas plant wastes. The raw effluents are directly neutralized with the proper proportion of lime, the

Nitrate Prevents Obnoxious Odors

DROUGHT or prolonged summer heat frequently overtaxes the usual sewage-disposal systems of a community and causes annoyance to local residents from objectionable odors. A more elaborate treatment or increased capacity of the plant might be considered. Since it is a temporary condition, however, the increased investment required is usually unwise because after the emergency is over, that added investment will remain idle and possibly the plant cannot even be expanded in time to meet the emergency.

To meet such a condition, a chemical treatment has been successfully tested and found suitable, of such simplicity that no plant investment is required. Where the odor is objectionable during a short season of extreme heat or where an extremely dry summer has reduced the water-flow so seriously that sufficient dilution of the effluent cannot be secured, the chemical treatment is used until normal conditions are again established, requiring no additional capital except for the actual cost of the chemicals.

Nitrate Reduces Odors

Reduction in odor depends on preventing the formation of hydrogen sulphide from the decomposition of sulphide compounds in the sewage effluent. It is known that this decomposition will not occur as long as there is oxygen from the air dissolved in the effluent, or oxygen from a chemical source which is more available than the sulphur compounds. Sodium nitrate has been found to be a suitable chemical for this purpose. Containing more than 50 per cent oxygen, it is particularly suitable because it does not decompose until it is put to use, but is immediately available as soon as its oxygen content is required. It is easily handled and stored as a clean white solid which is readily soluble in water, leaving no sediment as a result of its reaction.

Under certain conditions, chlorine has been found to be very satisfactory, but for the control of odor the use of sodium nitrate has been found more economical and suitable. Successfully used on the Neponsit River near Boston, Mass., and subsequently applied in several places in Wisconsin, it is now receiving its first real test in a large city. The addition of one pound of nitrate to each thousand gallons of sewage is calculated to give effective results. However in a recent test, encouraging results were obtained by using only one quarter of that amount.

Treatment at Coney Island

Through the Department of Sanitation, the City of New York is testing this treatment in a particularly difficult situation in Coney Island Creek. Objectionable odors near the bathing beach and in a heavily populated residence district have been an annoyance each summer during the two warmest months of the year, just when the bathing crowds are at the peak.

The creek was first treated by an initial application of chlorinated lime. This was followed by daily doses of sodium nitrate applied at such stage of the tide as to conserve the chemical. The treatment this summer was of an experimental nature, but results obtained seem so favorable that the department hopes to be able to expand the work in 1932 so that a complete alleviation of the conditions can be looked for.

Chlorinated Copperas Used In Water Purification

By
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The purification of water and the treatment of sewage are important markets for chemicals. The following percentages are consumption of domestic production: alum, 60; chlorine, 16; chemical lime, 6.9; and soda ash, 3.6. And large quantities of ammonia, copper sulphate, iron salts, sodium nitrate, and other chemicals also are used for these purposes

PROBABLY the most interesting part of this particular phase of trade-waste disposal is the partial elimination of the waste pickling-liquor problem by recovery of the copperas for use in water purification and sewage treatment.

Ferrous salts, particularly copperas, have been used for many years in purifying water, but it was comparatively recently that the objectionable accompanying alkali dose has been made unnecessary by conversion of the ferrous salts to their more active ferric state by chlorination. In most cases the optimum coagulation point of raw water with copperas is well on the alkaline side, thus usually necessitating the addition of alkali to insure removal of suspended matter and added coagulant. The simple addition of chlorine to copperas solution quickly and economically forms a ferric coagulant which readily breaks down the electrical stability of the colloidal impurities. As a result flocs are formed varying from trivalent iron plus colloids, ferric chloride and sulphate plus colloids, to true ferric hydroxide, depending upon the nature of the suspended matter and their isoelectric pH values. Thus vegetable colloids present largely as "color" will usually form ferric "lakes" at low pH values (3.6 to 5.2), and will remove this color more completely than alum will because of the greater affinity of trivalent iron and the negatively charged color colloids, as compared with trivalent aluminum ions.

Bivalent ions form no such compounds and depend upon the formation of insoluble hydroxides at alkaline pH values to remove suspended matter. Neither ferric nor ferrous hydroxides exert appreciable coagulating effect on colloids having isoelectric points below 7.0.

The preparation of chlorinated copperas is accomplished readily either by the batch or continuous flow method. In the former method the chlorine is diffused into a given quantity of dissolved copperas until the necessary ratio of one part chlorine to each seven- and eight-tenths parts copperas is reached. The resultant ferric solution is used in a constant head, variable orifice device, similar to the familiar alum-solution feed.

In the more popular continuous flow method the discharge from a dry feed copperas machine is merged with the discharge solution from a solution-type chlorinator. The definite mathematical ratio of chlorine to copperas is maintained by the machine settings which are sufficiently accurate for all practical purposes. Oxidation control is maintained by qualitative tests for bivalent iron with potassium ferricyanide except where prechlorination is practiced, in which case the presence of any residual chlorine after floc formation is considered conclusive evidence of complete oxidation.

Copperas From Pickling Liquors

Chlorinated copperas has a distinct advantage over alum where appreciable organic matter must be removed and, when considered on the basis of their water-soluble oxides, is as effective as alum on turbid waters. Its principal disadvantage is the reddish brown color of its precipitate as compared with the white alumina deposits when faulty control permits coagulant to pass into the distribution system.

Aside from the lessened stream-pollution load by copperas recovery from waste pickling liquors, the most important use of iron salts in waste-disposal practice is in the manufacture of fertilizer in the activated sludge type of municipal sewage-disposal plants. In this process coagulation of putrescible matter into settleable particles and stabilization of dissolved matter are accomplished by the combined physical and biochemical action of aerobic organisms in the presence of artificially supplied air.

The disposal of the excess sludge constitutes quite a problem, because its

tenacious adherence to the water of hydration makes it difficult to dry or convert into an easily packaged form. Chemical dewatering is practiced in plants where the sludge is not digested. Some of these plants simply condition the sludge with ferric chloride before drying it on sand beds and using it to fill low grounds. The majority employing ferric chloride for dewatering use it in conjunction with mechanical filtration and drying for the production of fertilizer in a salable form. It is a most powerful and satisfactory coagulant for this purpose and is used wherever available at favorable prices. Some plants, notably Houston, Tex., because of the great distance from the manufacturers of ferric chloride use chlorinated copperas with good results. The consensus of opinion is that ferric chloride is the most satisfactory conditioner known at this time.

Ferric Chloride in Dewatering

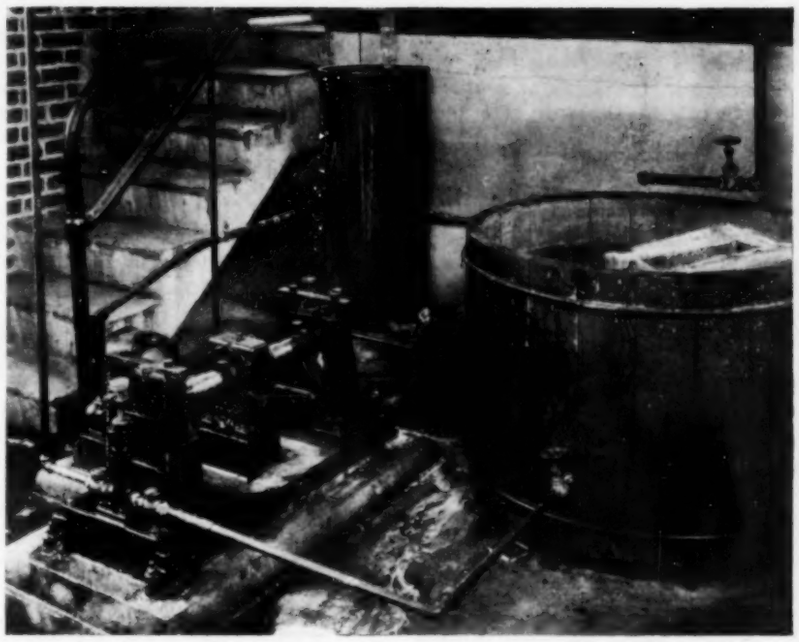
Applied just prior to vacuum dewatering at rates varying from 100 to 300 lb. per ton of dried sludge produced, ferric chloride assists in satisfactory dewatering so that the filters produce a compact damp cake of fertilizer. In small plants the damp cake is loaded direct into farmers' trucks without further treatment, but the larger plants, such as Milwaukee and Indianapolis, dry their product in heated rotating drums. This method produces a dry fertilizer which is shipped to consumers or to commercial fertilizer companies for incorporation with other constituents into standard brands.

Similarly ferric chloride is used before filtration as a dewaterant in protein recovery from packing house wastes, producing a feeding base comparable to tankage, and partially eliminating a troublesome stream-pollution problem.

It is the practice in sewage-treatment plants of the separate sludge digestion and Imhoff types to use ferric chloride to dewater partially the digested sludge where the area of the sludge-drying beds is insufficient to take care of the sludge production. Mixed thoroughly with the discharging sludge it causes rapid drying on the sand beds and permits early removal.

Precipitation in Raw Sewage

Considerable work has been done, notably at Dearborn, Mich., and Wilmington, Del., toward precipitation of putrescible matter in the raw sewage to promote easy separation and disposal. Although chemical precipitation in raw sewage has been more or less discredited during the rapid improvement of biological methods of disposal, it appears that the subject has not been entirely exhausted and that valuable contributions to the public health engineering profession will be forthcoming from this and similar experimental projects.



Proportioner Installed in Pump House; Pumping Solutions of Alum and Sodium Aluminate for Coagulation, Clarification and Softening of a Muddy Water

Alum and Aluminates In Water Treatment

By
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THE position of alumn and aluminates in the field of waste and waste-water treatment is the same as that of chemical treatment in general, and their application is limited to a few minor instances in which the total tonnage used is negligible. The cost of the chemicals is justified only under emergency conditions, unless the quantity of water treated is sufficient to obtain the lower price schedules on large tonnages, or unless water is scarce and the treated water may be re-used in the process. However, that the cost is not excessive in cases where proper combinations of chemicals and chemical control are applied has been demonstrated in various plants. A continuation of the trend toward the closing of process-water systems such as is manifest in certain industries, and closer restrictions on stream pollution undoubtedly will bring chemical treatment into its own, and coagulants such as alum and aluminate will be in demand in this field.

Alum finds application in the treatment of raw water for the purpose of coagulation, and sodium aluminate is used as a combined coagulant and softening agent. Their applications therefore may be treated under two classifications; viz., clarification and softening.

The fundamental theories of coagulation have received considerable attention in the technical literature within the past few years and space does not permit a discussion of these theories here. It must suffice to state that chemical coagulation is essential to our so-called American system of rapid filtration, and that alum and aluminate are used to produce a floc. Practically all suspended matter and bacteria are absorbed and entangled by the floc, the resulting coagulum forming a mat on the filters thus reducing or preventing the impregnation of the filter bed, making back washing more successful and materially prolonging the filter life. Alum is used with waters containing sufficient natural alkalinity to promote the hydrolysis of the salt to aluminum hydroxide, but in some cases alkalinity in the form of lime or soda ash must be added. The range of pH for satisfactory coagulation with alum lies between 5 and 7.5; the optimum is dependent upon the nature of the raw water but probably in the majority of plants is about 5.5. Most colloidal particles present in natural waters are negatively charged, and the

maximum adsorption of positive aluminum ions takes place and best coagulation usually is accomplished at the lower pH. This is generally true of organic colors, in particular, in naturally colored waters.

Since the introduction to the market of sodium aluminate it is frequently used along with reduced dosages of alum, and supplies the required alkalinity as well as improves the results, as there is less mud-ball formation, less back washing and longer filter runs, more rapid floc formation, and better hydrogen ion concentration in the finished water. The range of pH for satisfactory coagulation is broadened materially by the reaction of sodium aluminate with the magnesium of the water to form magnesium aluminate, which is insoluble at high pH values. In general the aluminate dosage required is between 0.1 and 0.2 grain per gallon along with approximately four times this quantity of alum. Sodium aluminate rarely is used alone. The alum dosages when this coagulant is used alone will vary quite widely, depending on the alkalinity and the organic and suspended solid content of the water, but an average dosage is approximately one grain.

The hardness of a water treated by the standard lime and soda ash process is rarely reduced below three grains, and in order to obtain good coagulation and rapid settling, and to reduce the hardness much below this figure a coagulant must be used. For municipal supplies alum is commonly used, but for industrial waters sodium aluminate is more generally applied. Aluminum sulphate, ammonium or sodium alums were formerly used rather extensively as the coagulant, particularly in ice plants. Aluminum sulphate is frequently applied as a supplementary treatment following the softening of water by lime, in the manufacture of ice. This is done for the purpose of reducing the alkalinity.

For boiler-water supplies it is necessary to reduce the dissolved and suspended solids to the minimum, and since the use of alum increases the dissolved solids, aluminate is to be preferred. Better coagulation also is frequently obtained because of the more effective action of aluminate at the high hydrogen ion concentration of the softened water (pH above 10), and more effective removal of finely divided colloidal and suspended solids is accomplished. For high-pressure boilers or in any case where conditioning with phosphate is practiced the lower hardness of the aluminate in the softener reduces the quantity of phosphate required and makes the treatment more economical. Silica is also reduced to the minimum by the formation of calcium or magnesium aluminosilicate in the softener and by carrying a residual alumina content equal to or higher than the silica. Any silica going to the boilers will be precipitated, as the aluminosilicates which are non-adhering and non-scale forming and the troubles due to hard silicate scale are thus eliminated.

For internal treatment of boiler water both coagulation and softening are required together with silica removal. The dosage of sodium aluminate required for floc formation and silica removal usually is not sufficient to remove hardness and to give proper excesses of treatment. While complete softening can be obtained with aluminate it is more economical to use only sufficient sodium aluminate to precipitate silica and to give good floc formation, and then to apply auxiliary chemicals, such as soda ash, to complete the softening and provide proper excesses. The hardness, silica, alumina, alkalinities, chlorides, sulphate, and solids can be determined by simple tests and must be controlled to assure a properly conditioned boiler water. The dosages of sodium aluminate required are dependent, therefore, upon both physical and chemical effects, the treatment being determined by good flocculation and the desired reactions in the boiler water.

Wayside water treatment, such as is practiced by all railroads, consists in the automatic proportioning and feeding of the chemical into the raw water. This is done as it is being pumped to the wayside tank, from which the treated water carrying any precipitated solids is taken into the tender. The principal reaction takes place within the boiler; incrusting hardness is coagulated and thrown down as a flocculent sludge, and is removed by the use of blow-off cocks when blowing down to reduce the concentration of dissolved solids. For this wayside treatment sodium aluminate solution, containing sodium hydroxide and tannin, is used in a quantity sufficient to react completely with the incrusting sulphates in the raw water, and to give a minimum of one grain excess alkalinity over the hardness. The tannin is used in this application to reduce incrustation of the injectors which are used on many roads to feed the water from the tender to the boiler.

Notwithstanding the fact that the majority of those industries which generate large amounts of power, now condition water in some fashion, water treatment in industrial plants had until recently received even less consideration than was accorded it by the efforts of the engineers of the railroads.

Railroads Treat Boiler Water With Aluminates

Active Carbon Treatment

WIDER appreciation of the use of activated carbon in removal of taste and odor from water has come only in recent years, and especially since the introduction of the powdered form. Applied in the granular form, activated carbon requires filter beds, but is sometimes the best alternative in year-around operation.

Because of its fineness (94 per cent through a 200-mesh sieve) powdered active carbon is effective in a correspondingly high degree. In practical application it is fed to the body of water being treated at determined rates through dry-feed machines equipped with injectors to distribute the resulting water-carbon suspension. It is introduced at one or more stages prior to sand filtration of the water.

The South Pittsburgh Water Co. was experimenting several years ago with activated carbon for the absorption of phenol wastes from the Monongahela River. Through its regular sampling operations an unusual quantity of phenol was once detected, tracing to an accident at a byproduct plant above. An emergency treatment with activated carbon immediately gave an entirely satisfactory effluent. Up to the present time close to 100 installations of activated carbon treatment for water purification have been made within a comparatively few months, and all are said to have given entire satisfaction.

SPECIFICALLY, what has industry accomplished by way of putting its back yard in order? The answer, of course, must largely depend on the nature of each individual plant's operations; and this will also modify the very extent to which by-product treatment is carried. Cases range from those in which even a permissible minimum of control can be exercised only at great monetary loss, to those in which disposal of wastes has been converted into a highly profitable "side line." Since both cases are solutions of the same basic problem, it is hoped that the various selected examples of practice from chemical engineering industries offered here may serve as instructive illustrations to the text already preached throughout the foregoing pages.

Petroleum Refinery Effluent Treatment

By

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TRADE WASTES to be disposed of by a refinery may be liquids, gases and vapors, solids or semi-solids. As a rule, the refinery's major waste problem is concerned with the disposal of liquids, for this is the one form of waste that, in almost every case, reaches beyond the confines of the plant, and is discharged into some body of water or drainage channel.

Water is used in relatively large quantities for condensing and cooling the products formed when distilling crude petroleum or its derivatives. In smaller quantities it is used in the chemical treatment of semi-refined products when converting them into finished products; for general cleaning and washing purposes; for sanitary and wash purposes in change or wash houses; for boiler feed water; and for miscellaneous other purposes. Practically all crude petroleum as received at the refinery contains some water, which settles out as the oil stands in storage tanks and is periodically withdrawn. Steam is used in many of the distillation processes, is condensed with the oil vapors, and settles out in the tanks containing the semi-refined products, or is separated from these products by traps, or water separators, before reaching the tanks.

Depending upon whether or not the water used for condensing and cooling the distillation products is cycled for cooling and reuse, part or all of the water used or collected within the refinery eventually finds its way outside the limits of the plant. Oil from innumerable sources finds its way into the water drainage channels of the refinery, and the problem then is to free the water of its oil content before the effluent from the drainage system leaves the plant boundaries.

Separating Oily Effluents

The usual method of preventing the escape of oil from refinery property is by means of a comprehensive drainage system and one or more main gravity-type oil separators of sufficient capacity to retain the oil and sediment. Auxiliary gravity separators may be used ahead of the main separators at points where slowly separating emulsions or large quantities of oil originate. In this way, much of the oil is collected near the source, and to that extent relieves the main separators of the burden of separating it from the water.

The drainage system of a modern refinery usually consists of two or more separate systems of sewers. As a rule, these consist of a sanitary system for conveying sanitary waste from change houses, office buildings and latrines to purification tanks, and of a much larger system for conveying water and oil waste to the separators. Some refineries provide a separate system for conveying the comparatively oil-free cooling water from the condensers, while some may provide a separate system for storm-water drainage. All of these systems eventually discharge into a separator, or separators, so that oil may be trapped off before the water leaves the plant.

The separator used almost exclusively by the refining industry is the gravity type. In form it is a rectangular box divided into compartments by baffles extending from above the surface of the water to a point about half way from water surface to the floor. Usually its capacity is made sufficiently great to permit dividing it into two or more sections by longitudinal walls, so that one section at a time may be taken out of service for repairs or cleaning without destroying its effectiveness in separating oil from water. A gravity system is illustrated on the next page.

The functioning of the gravity type separator depends upon the difference in gravity of oil and water. The oil, being usually the lighter liquid, rises to the surface, is retained by the baffles, removed from the compartments by a system of skimmers, and transferred to tanks for further use.

Gravity separators will not prevent the passage of emulsified oils. There-

fore, to prevent the escape of oil from the refinery, emulsions should be broken before being discharged to the plant drainage system, and thus prevented from reaching the main separators. Nearly every case of refinery emulsion involves some special chemical problem, and will require study by the plant chemist before a method of breaking it can be evolved. Suffice to say, if trouble is to be avoided and the effectiveness of the main separator is to be maintained, emulsions should be destroyed before being discharged to the sewers.

Counteracting Residual Chemicals

Chemical wastes from a refinery, as a rule, find their way into the drainage system and are discharged from the property with the waste water. The waste chemical comes largely from the treating processes for refining both light and lubricating oils, although the crude oil as received at the refinery may contain small quantities of chemicals.

The chemicals used in many of the processes for treating oils are withdrawn from the system and reclaimed for further use; therefore, the quantity going to waste is relatively small. Dilution with the much larger volume of waste water reduces the concentration of the chemical waste to such an extent that it is generally harmless to humans, to fish or animal life, or to vegetation. Added dilution in the body of water into which the waste water discharges still further reduces the chemical concentration.

Acid sludges derived from treating oils may be burned as such, or the acid may be separated from the sludge and reclaimed for further use. In the latter case, the residue left after separating the acid may be burned without further treatment, or it may be neutralized with lime or caustic soda and mixed with fuel oil before burning. A liquid fuel of fair quality can be made by this method. Some acid sludges, or the residue obtained after separating the acid, will become solid or semi-solid upon standing a comparatively short time. These waste products are then burned upon specially designed stokers or in specially designed burners, and make a fairly satisfactory fuel. The main problem, however, is the disposal of a waste product.

Except in a very few instances, the disposal of waste gases and vapors has not been a problem of great moment with refiners. Some refineries located adjacent to closely built-up residential districts have had to solve the problem of satisfactorily disposing of waste gases and vapors from the refining of crude oils high in sulphur content. Others have had to solve the problem of satisfactorily burning acid sludges without creating a nuisance.

Varying quantities of solid waste, such as spent filtering clay, cinders and ashes, still cleanings, coke, brick and mortar, scrap metal, scrap lumber, rags and waste, rubber goods, glassware, etc., accumulate and must be disposed of. Some of these materials have sufficient value to pay for salvaging them. Most scrap metal has a sale value. Coke, lumber, rubber goods, and other combustible materials are disposed of by burning. Cinders, ashes and spent filtering clay may be used for filling material within the plant, or often can be sold for that purpose.

Those interested in the subject of disposing of waste water containing oil will find much valuable information in Section I of the Manual on Disposal of Refinery Wastes, prepared by the Committee on Disposal of Refinery Wastes of the Division of Refining, American Petroleum Institute.

Useful Conversion of Refinery Byproducts

By
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MANY BYPRODUCTS of petroleum refining usually considered as wastes are now being successfully treated to obtain one or more marketable products of sufficiently greater value than the original material to make the treatment profitable. With the possible exception of refinery gases, the treatment of byproducts is as yet not general and many of the processes employed at present are of experimental or semi-commercial size. The results obtained, however, are very promising and the near future may see a number of large commercial-size installations for treatment of petroleum coke, heavy residues, refinery sludges and refinery gases.

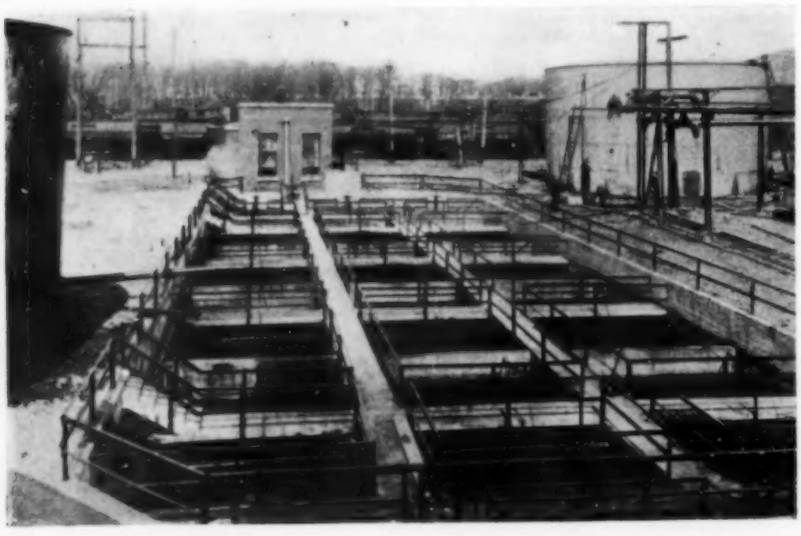
A large number of petroleum refineries are confronted at present with the disposal of petroleum coke, sludges produced by chemical refining of petroleum products and heavy semi-liquid and liquid residues from atmospheric or pressure distillation, particularly the residues containing a high percentage of solid suspended matter or emulsified water.

Petroleum Coke as Fuel

Many refineries have been using these products as fuel within the refinery for a number of years not so much for their fuel value as to eliminate the nuisance and fire hazard connected with their storage or their burning in the open. Gradually methods were developed by the refineries not only just to burn these products but to recover efficiently the heat available from their combustion.

Recently fuel users outside of the refining industries, located close to a source of refinery waste products have started using them with a marked de-

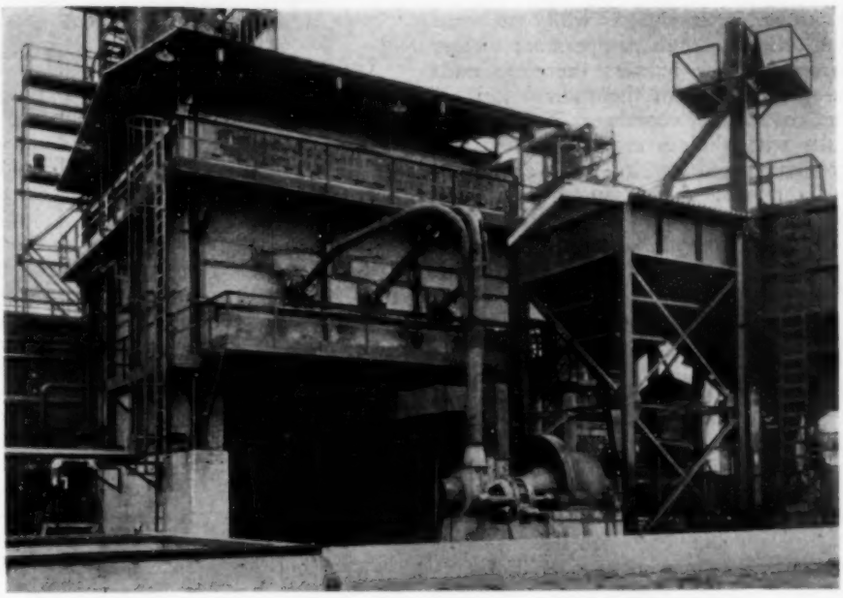
Gravity-Type Separators in Use at Refineries to Retain Oil on Property in Discharge of Effluents



gree of success for power generation, metallurgical purposes and other uses where heat is generated in large quantities per fuel consuming unit. One public utility company built a power plant in the vicinity of a number of refineries producing petroleum coke in large quantities and has been operating this plant with petroleum coke as the only fuel. Another public utility company supplying power to a refinery is accepting all the carbonaceous waste products of the refinery as part payment for the power supplied and is burning these products with an efficiency and ease of control comparable to standard fuel oil and natural gas burnt in the same plant.

Petroleum coke is an ashless, smokeless, solid fuel containing 85-95 per cent of carbon and 5-15 per cent of volatile matter and having a gross calorific value of 14,500-16,000 B.t.u. per lb. As shown by a number of years of practical experience, petroleum coke is ideal for powdered fuel firing. Due to the low ash content of petroleum coke, the usual problems of powdered coal firing, such as fly ash, slag removal, corrosion and erosion of brick settings, are almost completely eliminated when petroleum coke is used. However, successful burning of petroleum coke has its own problems, which are caused by moisture and stray iron usually present in the coke because of the methods used in the removal of the coke from the vessels in which it accumulates, and by occasional wide variation in volatile matter because of improper operation of the processes producing the coke.

A properly equipped powdered coke installation contains as a general rule a storage bin of sufficient capacity to permit at least 24 hours' weathering for fresh coke to drain off moisture. Then there is a set of coarse grizzlies over the hopper, feeding the crusher to remove the larger pieces of stray iron and the extra large lumps of coke which usually contain the bulk of very hard or very pitchy coke, and a set of fine grizzlies after the crusher to separate the bulk of stray iron and pitch (the pitch is usually flattened out but not broken up by the crusher). Finally, there is a magnetic separator to separate the small pieces of iron. With such an installation only dry petroleum coke, free of iron and the major portion of pitch or hard coke, is fed to the pulverizer and the burners so that steady controllable fires are obtained. A number of installations are burning petroleum coke in boilers with an efficiency of 80 per cent for the boiler alone and better than 85 per cent for the boiler and economizer.



Petroleum Coke as Refinery Fuel: Hardinge Ball Mill in Center Feeds Coke From Hopper to Foster-Wheeler Tube Still

Refinery Sludge Treatment

Treatment of acid sludges to recover oil and acid is probably one of the oldest byproduct recovery processes used in the refineries. The sludge is cooked with steam and water to separate it into free oil, weak acid and reaction products. The oil obtained is sold as high grade fuel or used as charging stock for cracking processes. The weak acid is either concentrated for further use in chemical treatment of petroleum products or is sold as weak acid for etching and cleaning metals. The reaction products are usually burned in the refinery. Considerable research is now carried out on the treatment of the reaction products for the recovery of sulphonic and other organic acids as well as using the sludge as raw material for a number of synthetic products.

Refinery sludges as produced are viscous liquids or semi-solids and consist of a mixture of water, free acid or alkali, oil and the reaction products. Their calorific value on a dry basis is 10,000-14,000 B.t.u. per lb. Efficient burning of sludges, particularly raw sludges, as fuel, is comparatively recent, and those produced from refining cylinder stock and bright stock are most satisfactorily burned in outside rotary burners. These burners are up to 8 ft. in diameter and 20 ft. long, acting as a coking still and ignition chamber where approximately 80 per cent of combustion is completed. The sludges are kept in constant agitation by the rotation of the burner so that fresh surfaces are exposed to the combustion air admitted into the burner by means of a forced draft fan. With an auxiliary fuel such as oil or gas to take up sudden variation in fuel requirements even the heaviest semi-solid sludges are burned under boilers with better than 70 per cent thermal efficiency and give satisfactory control of the fires.

Sludges produced from refining the lighter oils are burned successfully in special fuel oil systems, particularly if the sludges are blended with various oils or chemical stabilizers to make them sufficiently fluid and stable for pumping. To avoid precipitation of the solid particles in the sludges and consequent plugging up of the lines, the regulating valves and the burners, the sludges are kept agitated in storage tanks and in constant circulation in the distributing lines. As a general rule 3-4 times the amount burned is circulated through the lines and the excess returned back to storage.

Handling Active Sludges

With very few exceptions refinery sludges are either strongly acid or alkaline and therefore require corrosion resisting materials for the lines. Mixing alkali and acid sludges in proper proportions to neutralize each other, may simplify the transportation problem provided the mixing does not coagulate and precipitate the semi-solid particles of the sludges. As a general rule, separate lines are provided for the transportation of the alkali and acid sludges and separate burners for their burning.

Because of their physical nature sludges cannot be atomized in conventional fuel oil burners, particularly those with small orifices. When burned in large quantities per burner, the sludges are best atomized in mechanical burners where atomization is obtained by imparting a high velocity rotary motion to the sludge stream before it leaves the burner tip. In small quantities sludges are successfully atomized with steam or refinery gases in modified impact atomizing burners in which the atomizing medium is introduced into the burner nozzle tangentially near the tip, through a number of holes at an angle to the flow of the sludge.

Combustion Characteristics

Sludges usually have a much higher flash point and burn considerably slower than standard liquid fuels so that high combustion temperature must be maintained to completely burn the sludges.

However, most sludges will coke when subjected to high temperature before ignition. The burners therefore must be protected from the radiant heat of the combustion chamber. The best results with sludges are obtained in fuel consuming units with a small amount of radiant heat absorption so that high combustion-chamber temperatures are obtained and with burners so installed that the tips are out of the heat zone. As a general rule the air for combustion is introduced around the burner for additional cooling of the tip.

Burning of heavy liquid and semi-liquid residuums containing a high percentage of solid suspended or easily precipitated dissolved matter is somewhat a simpler problem than burning sludges. The residuums are usually more fluid, noncorrosive and are not as easily coked or coagulated as most sludges. An installation successfully burning sludges would easily burn the worst residuum. Some refineries are burning residuum containing as high as 40 per cent B.S. & W. in the furnaces of their cracking units without auxiliary fuels and obtain the close regulation required of such furnaces.

Refineries with a large number of cracking installations, especially those producing high anti-knock motor fuel, obtain as a byproduct large quantities of refinery gases. These gases consist mainly of methane, ethane, propane, butane and their derivatives and in their burning characteristics closely resemble the higher calorific value natural gases.

Refinery Gases as Fuels

Since the quantity of refinery gases produced is usually not very constant the gas distributing lines are so arranged that one set of fuel consuming units (usually the boilers) burn only the excess over the requirements of units having first call on the gases produced. When the gas production varies within wide limits the gas consuming units are divided into a number of groups, each group consuming only the excess of gas from the unit ahead of it in preference. This is usually accomplished by means of automatic pressure regulating or reduction valves.

Burning refinery gases alone presents no problems, particularly if the gases do not contain appreciable quantities of mechanically occluded light liquid hydrocarbons which, if coming in slugs, may affect the regulation of the burners and eventually may carbonize or burn out the burner tips. Where other refinery byproducts are burned as fuels refinery gases are often used to facilitate their combustion and obtain closer regulation of the fires. A number of refineries obtain automatic controls on furnaces in which up to 80 per cent of the average heat load is supplied from byproduct fuels burned in substantially constant quantities and the variations in load are taken up by automatically changing the quantity of refinery gases used.

Refinery-Gas Treatment

Utilization of refinery byproducts as fuels while successful from the technical and often the financial point of view is not the best method of their disposal. Most of the byproducts have greater intrinsic value than just being competitors to cheap coal or oil.

Treatment of refinery gases is therefore becoming more or less universal. As a general rule they contain from 0.5 up to as high as 7.0 gal. of liquid hydrocarbons which when recovered and blended with motor fuels improve their volatility and anti-knock properties. The liquid products are now being removed from the gases by absorption, compression, refrigeration or a combination of these methods. The dry gases are often fractionated to separate and liquify the propane and butane which are now finding continually increasing use both in industry and as domestic fuel in localities where manufactured or natural gas is not available.

Approximately 30,000,000 gal. of liquified refinery gases have been sold for these purposes in the United States in 1930. Among the possible important uses of butane in the future is its substitution for acetylene in welding. A number of refineries are successfully doing all their welding with butane, and some are reporting even better results than those obtained with oxy-acetylene.

Cracking or reforming of gases to yield benzol, butyl alcohol, methanol and similar products, particularly those suitable as solvents for lacquer and other cellulose products, is now being done commercially both in the United States and abroad. The halide derivatives of the lighter hydrocarbons obtained from refinery gases form a series of valuable products important as resins and impregnating materials.

While considerable progress has been made in recent years to treat refinery byproducts, the field is barely scratched on the surface. With further development along these lines there is no reason why the so-called wastes of petroleum refining should not yield upon treatment a series of byproducts similar to those obtained from coal tars.

Waste Metal— A Huge Industry

THE RECOVERY, treatment, and use of waste mineral materials in the United States represents in normal times a half-billion dollar industry, according to a recent report of the U. S. Bureau of Mines. Secondary metals—i.e., those recovered from scrap metal, sweepings, skimmings, and drosses—have become increasingly important in recent years. More than 500,000 short tons of copper is recovered annually from brass and other scrap metal. Secondary lead production amounts to approximataely 300,000 short tons, equal to 40 per cent of the total refined primary lead produced. The main sources of supply of secondary lead are battery plates, lead cable, lead pipe, and lead lining of acid tanks, but large quantities are derived also from babbitt, solder, type metal, terne metal, brass, and white metal drosses.

The recovery of secondary tin in the United States is equal to about 41 per cent of the tin imported as pig metal, and in normal times is valued at $30,000,000 to $35,000,000. Nearly all detinning in the United States is done by the electrolytic process or the chlorine process. Several plants are equipped to handle 40,000 tons of old tin-coated containers, but they have never operated at full capacity. In recent years only small quantities of old cans have been treated, even when the price of tin was much higher than at present.

The accompanying table, released by the U. S. Bureau of Mines Aug. 13, 1931, does not include scrap iron and steel nor the precious metals which in the aggregate value constitute an important percentage of the total output of secondary metals.

Secondary Metals of Certain Classes Recovered in the United States, 1929-30

	1929		1930	
	Short Tons	Value	Short Tons	Value
Copper, including that in alloys other than brass	417,600	$146,995,200	332,800	$86,528,000
Brass scrap remelted	296,500	76,000,000	192,000	39,000,000
Lead as metal	138,500	39,186,000	129,000	25,580,000
Lead in alloys	172,500		126,800	
Zinc as metal	65,400	10,164,000	49,300	5,472,000
Zinc in alloys other than brass	11,600		7,700	
Tin as metal	7,400	30,513,300	5,600	16,228,300
Tin in alloys and chemical compounds	26,900		20,600	
Antimony as metal	52	1,990,200	8,082	1,239,800
Antimony in alloys	11,079			
Aluminum as metal	25,850	23,135,200	19,700	17,177,000
Aluminum in alloys	22,550		18,900	
Nickel as metal	850	3,045,000	500	2,030,000
Nickel in nonferrous alloys and salts	3,500		2,400	
Total value	.....	331,028,900	.....	193,255,100

Disappearance of the "Gas-House District"

By
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Koppers Research Corp.
Kearny, N. J.

IT HAS been rather common for novelists and cartoonists to refer to the "gas-house district" as the most unpleasant spot in a civilized community. Possibly one reason for this was the disagreeable odor from the little creek or river that acted as the flushing medium for every waste product from the plant. However, such conditions fortunately ceased to exist a generation ago.

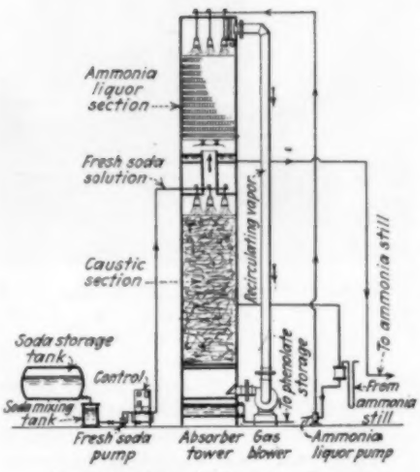
Nearly all of the manufactured gas in this country is made by either of two general processes: (a) coal carbonization, such as in coke ovens or coal-gas retorts, and (b) carburetted water gas. The effluents from each type of process are quite different and must be discussed separately.

Ammonia-Still Wastes

In coal-carbonization plants, ammonia-still waste probably constitutes the most serious disposal problem. This is the residuum liquor after the free and fixed ammonia have been distilled out of the ammonia liquor. A superficial examination of this still waste would give the impression that it would cause no nuisance if disposed of by running into a stream, since it is a relatively clear solution, having no very bad odor. This would be true were it not for its content of phenols, which is usually between 2 and 4 grams per liter. These are enormously diluted when run into a stream, but even so, subsequent chlorination of such water for city use produces chlorophenols, which impart a medicinal taste in drinking water that is quite disagreeable to most people.

Still waste may properly be disposed of by one of three general methods: (1) Complete evaporation. (2) Removal of phenols at plant before running into a stream. (3) Mixing with sanitary sewage.

Any practical process for evaporating still waste depends on heat that would otherwise be wasted. The quenching of hot coke from the ovens is the usual source. The chief advantage of this method of disposal is that it entirely eliminates still waste as a liquid effluent. The disadvantages are many, including corrosion to plant equipment by the calcium chloride contained in still waste, the poor appearance and odor of the coke, and possible contamination of the air with odors.



Arrangement of Koppers Process for Dephenolization

Processes for removing the phenols from still waste before discharging it into the streams are fairly numerous, but all depend on one of four principles: (a) extraction with solvents, (b) distillation, (c) adsorption, and (d) bacterial action.

Phenol Removal

Processes involving the use of solvents have found considerable favor, possibly in Europe to a greater extent than in this country. The solvent is almost invariably applied to the ammonia liquor before the still, rather than to the still waste. The process consists essentially of bringing ammonia liquor and light oil or benzol into intimate contact. The larger part of the phenol passes into the light-oil layer, which is then decanted. This is treated with caustic soda and the resulting sodium phenolate may be sprung by sulphuric acid or carbon dioxide. The dephenolized light-oil passes back into the process to be used again.

The most widely used distillation method of still waste dephenolization is the Koppers vapor-recirculation process. The liquor is dephenolized after passing through the free-ammonia still, but before passing on to the fixed-ammonia still. In other words, the distillation treatment of the ammonia liquor is carried out in three separate stills, instead of the two usually used, the middle still being the vapor-recirculation dephenolizer.

The dephenolizer consists of a tall, packed tower, as shown in the flow diagram, through which vapor (mostly steam at a temperature of about 100 deg. C.) is passed continuously from the bottom to the top, and recirculated back to the bottom through a downcomer. Phenol is removed from this vapor in the lower sections of the tower by means of hot 10 per cent caustic soda solution, and this dephenolized vapor then distills the phenol out of the liquor in an upper section, through which the liquor flows down countercurrently to the hot vapor. In other words, the recirculating vapor serves as a carrier for the phenol between the liquor and the caustic. Phenol is recovered from the sodium phenolate by springing with carbon dioxide (blast furnace combustion gas, for instance).

The third general principle of still waste dephenolization, namely, adsorption, has never been applied commercially in this country. Typical of the materials proposed for this purpose are animal charcoal, activated carbon, and lignite.

The fourth general principle of still waste dephenolization at the plant, bacterial action, has found no specific commercial application, although a good deal of experimental work has been carried on with bacterial filters.

Weaker Effluents

Of great importance, however, is the third method of disposing of still waste effluent, which depends on bacterial action, but which differs from the above in that this action takes place *after* the still waste leaves the plant. The simplest manner of applying this method is to run the still waste directly into raw sanitary sewage. In all sanitary sewage there are present certain aerobic bacteria which cause the phenol to be oxidized to carbon dioxide and water. This is, of course, the simplest and cheapest method of still waste disposal, but its success depends largely on a

large ratio of the sewage to still waste.

Aside from still waste, the chief phenol-bearing effluent from a coke plant is the final cooler water. Quite often this water is cooled for re-use by aerating sprays or towers, so that it never becomes an effluent. Also it is quite possible to use this water for coke quenching without the serious disadvantages of the use of still waste for quenching.

Non-phenolic effluents from a coke plant seldom involve any trouble in disposal. Typical of such wastes are the residual water from coke quenching, and producer-gas-scrubber water. Both contain coke breeze in suspension, but, after settling in a sump, such effluents can be run into a stream without involving any nuisance.

Acid-Sludge Recovery

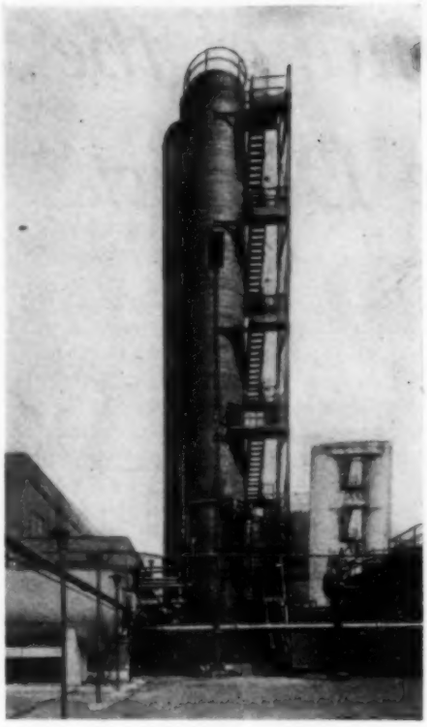
In coke plants that recover and purify light oil, the acid sludge from the sulphuric-acid treatment constitutes a disposal problem. A decided improvement in light-oil washing has been developed recently, known as the Ufer process. By this process, the formation of acid sludge is entirely eliminated in most cases, the recovered acid is suitable for use in ammonium sulphate production, valuable hydrocarbons formerly lost in the acid sludge remain as recoverable resins in the distillation residue, and wash losses are reduced.

The Ufer process differs essentially from the older light-oil washing processes in two respects. Instead of 66 deg. Bé acid, a slightly weaker one is used, and the temperature during agitation is usually controlled by cooling coils. After the primary stage of agitation is complete, water is added (about two volumes to one of the acid) and this causes the sludge (chiefly polymerized hydrocarbons) to dissolve in the oil, leaving the acid as a clean-cut layer that can be separated and run to the saturators for ammonium-sulphate production.

Water-Gas Byproducts

The handling of liquid effluents from carburetted water-gas plants is usually a somewhat simpler matter than those from coal-carbonization plants. The chief problem in effluent disposal from the former is the effective separation of tar and oils from the water, before running it into a stream. Usually proper designing of the tar separator, so as to secure complete gravity separation is all that is required. More recently, and in cases where the discharged water must be almost free of suspended tar and other matter, lime and alum or soda ash and copperas are added to secure a flocculation settling.

A rather common problem of the carburetted water-gas operator is the formation of very tenaceous emulsions of water-gas tar and water. Since usually these emulsions can not be discarded or sold, it is necessary to break the emulsion to obtain marketable tar and water clean enough to be run into a stream.



Koppers Dephenolization System in Operation

Many processes have been proposed and used for tar de-emulsification. Usually they depend on one of three principles: (1) centrifuging, (2) distilling, (3) hot settling. The latter is probably the simplest and cheapest, since it simply involves heating the emulsion almost to the boiling point of water, and then allowing a time factor (12-24 hours) for separation.

Disposal Critical for Beet Sugar Industry

WASTE WATERS from beet sugar factories represent a combination of waste products of widely different compositions, a fact which makes the problem of their proper disposal a very complex one. The volume of the waste waters is very large; considerable quantities of mud, lime and other insoluble solids are present, as well as appreciable amounts of soluble organic matter of very high oxygen consuming capacity.

The average beet sugar factory in the United States slices from 1,200 to 1,700 tons beets per day, and the main constituents of the waste waters are:

(a) Water from beet flumes and beet washer, carrying mud, sand, beet leaves, beet tailings and 0.03 per cent to 0.05 per cent sugar in solution.

(b) Pulp water drained from the exhausted beet slices (beet pulp). This water carries a small amount of suspended organic matter from the beets, sugar and mineral matter in solution.

(c) Lime sewage, which carries all of the calcium carbonate and organic matter resulting from the purification of the beet juices.

(d) Steffen waste water, containing all of the mother liquor remaining after sugar has been precipitated from molasses by means of the Steffen lime processes. Not all beet sugar factories use this sugar recovery process, but it is used by a large proportion of American sugar factories.

Probably due to the fact that sugar factories in this country are largely located in Western states of sparse population, and near rivers of considerable size, the problem of waste water disposal has been much less serious than in Europe. Consequently, very many more studies of sewage disposal have been made in Europe than in this country. In recent years, England has developed quite a beet sugar industry by means of a government subsidy, so a number of factories have been established on small streams serving rural districts. This has resulted in many complaints from fishermen and others, as well as in law suits, so the factories have been compelled to give serious study to the effluent problem.

The total volume of waste waters produced by an average American sugar factory of 1,200 tons daily capacity is about 5 cu.ft. per second, or about 5,000,000 gal. per day of 24 hours. This is a somewhat greater volume than for a European factory of similar size, because of slightly different operating practice in this country, and a tendency in Europe to use certain waters back. This plan of using return water in the diffusion battery and elsewhere is not looked on with favor in this country, as it tends to injure the quality of refined sugar produced by the factory.

Some of the factors which make the disposal of sugar factory wastes so much more difficult and expensive than is the case with other industries, are the following:

(a) Enormous volumes.

(b) They are produced in the late fall, when stream levels are usually low. At this time of year temperatures are low, so fermentation of organic matter proceeds slowly.

(c) A large portion of the waste water is extremely high in organic matter, requiring large surfaces and long time for oxidation. The Steffen waste water has an oxygen consuming power of 4,000 to 6,000 parts per million.

(d) Since a beet sugar factory operates only three months out of the year, a large capital investment for sewage disposal would represent a much greater overhead charge than for a plant working throughout the year. (A factory which made a large disposal installation some years ago is now in receivership, and closed down.)

It is generally agreed that the most injurious element in the waste waters, as far as fish life is concerned, is the organic matter. This is in sufficient concentration to use up the available

oxygen in the water of a small stream to such an extent that the fish are unable to get oxygen and consequently die. Underwood (*Ind. Chemist*, p. 260, June, 1927) quotes the following figures for oxygen consumed by the waste water of a large American sugar factory:

	Oxygen Consumed Parts Per Million
Beet carrying and washing water.	340
Battery waste water.....	960
Steffen waste water.....	6,500
Total sewage	230

As a result of some fifty years' study of the problem in Germany and other European countries, a great many methods have been proposed and tried on sugar factory sewage. Many processes tried have proved to be failures, and as yet there is no real agreement as to the best method. Some of the methods proposed are: (a) Sedimentation in large ponds. (b) Chemical treatment with lime, iron salts, etc. (c) Use of trickling filters. (d) Separation of various types of waste waters with treatment and filtration of best portions for return to the factory. (e) Activated sludge process. (f) Various types of biological purification.

Due to variations in cost of land, permeability of soil, volume of streams, etc., it is doubtful if any single procedure will ever be found the most desirable. After fifty years' study of the matter in Germany there is no single outstanding process which is recommended. Until such time as more research studies are available, the following procedure recommends itself as one which will accomplish the most with the lowest installation cost:

(1) Rigid separation of the various types of waste water.

(2) Large retaining ponds for the beet flume and washer water with final return of clarified water to the process.

(3) A series of separate retaining ponds for the pulp water and lime sewage, with overflow over shallow riffles between ponds and proper equipment to secure maximum oxidation of organic matter. After necessary retention period the discharge would go to the river.

If provision would have to be made for the Steffen waste water, the total area recommended to be available for the disposal system would be 75 to 100 acres. This is necessary to provide for retention time, change of ponds when subsoil becomes clogged, cleaning of ponds, and so on.

Finally, stress should be laid on the fact that the beet sugar industry cannot stand any appreciable financial burden in the way of new installations. At the few factories where a problem exists, it is important that the sugar manufacturers and the sanitation departments work out an efficient method of sewage disposal at a minimum of cost. If this is not done, and unnecessarily strict regulations are laid down, the final result may easily be the permanent closing of the sugar factory.

Putting Wood Wastes To Use

By C. A. BASORE

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WASTE WOOD can be classified conveniently as sawdust and shavings, sawmill and woods waste of large size, and bark. The production of the first group is very large. Prof. W. L. Beuschlein is authority for the statement that each mill producing 200,000 board ft. of lumber per day, after firing its boilers, will have 60 units of waste. At 12 lb. to the cubic foot this is equivalent to 144,000 lb. a day. A number of uses has been developed for sawdust and shavings, which in some cases seem profitable. One of the oldest uses for this refuse material is for fuel. If the sawdust and shavings are dry, they can be burned with no radical change in the fuel chamber or in the form of the material ("Outlets for Wood Waste," Forest Products Lab., Madison, Wis.). Often mill waste—i.e., sawdust and shavings—is mixed with coal, as fuel for sawmill boilers, laundries and small manufacturing establishments. To some extent sawdust and shavings have been used for fuel in gas producers. It is recommended that the sawdust be mixed with about 50 per cent "hogged" fuel for best results.

Briquetting Sawdust

Sawdust has been briquetted with binders and without binders. Briquettes made without binders often have advantages, such as cheapness of production, low ash content, and almost smokeless combustion. Interesting processes of this type include that employed by the Pacific Coal and Wood Co., by which the wood waste is briquetted under light pressure in a special brick press, the briquettes being bound with baling wire. The Arnold process consists of thoroughly drying the wood by steam pipes and briquetting at high pressure in a modification of the Exter press. A recent method (Basore: Bul. 1, Eng. Exp. Station, Ala. Poly. Inst.) consists of preheating the sawdust to 270 deg. C., moistening with water, and briquetting at 100 deg. In this way briquettes with a heating value of over 10,000 B.t.u. per lb. are produced at a very low estimated cost. Typical binders for briquetting sawdust include tar, pitch, clay, molasses, starch and similar products. Processes employing these binders seem to have no particular economic importance. In some cases there is a combination of distillation and briquetting.

Mechanical uses for sawdust and shavings include bedding for horses and cattle, ground covering in circus rings, flooring compounds, various molded articles, artificial wood, wood flour, gas purification, and filler for various types of concrete, stuccos, plasters, clay brick, and tiles. Chemical methods of utilizing sawdust and shavings embrace curing of meat, distilling raw sawdust, thereby recovering charcoal, tar, gas, alcohol and acetic acid, extracting rosin and turpentine with a volatile solvent, and producing ethyl alcohol. These methods are not very promising at this time.

Utilizing Coarser Waste

The coarser forms of sawmill and factory wastes have many uses. Tops of trees, crooked logs, etc., are often used for cord wood. "Hogged" fuel is employed considerably in large saw mills. Various mechanical uses for wood waste of this type are important. Much of it is used for the production of laths, shades, map rollers, chairs, matches, tooth picks, boxes and crates, and excelsior. Wood flour is made from shavings and sawdust, or from slabs and edgings. Fiber board is now made in large quantities from this waste by the Mason process.

The chemical uses of the coarser forms of waste wood are numerous. Much of the hardwood waste is distilled, the chief products being charcoal, tar, alcohol, and acetic acid. Softwood (pine) is often extracted with gasoline or steam and the rosin and the turpentine are recovered. Under certain conditions this method apparently is profitable. The manufacture of paper from wood waste has proved to be a promising outlet for this material. For years paper has been made from slabs and other large pieces of hemlock and spruce. Several mills in the South utilize yellow pine mill waste. These mills use almost exclusively the sulphate process of pulping. The so-called Kraft or yellow paper is produced by this process, but Dr. Charles Herty states that a white paper can even be obtained from the slash pine. This has interesting possibilities. The economic aspect of the recovery of several products from the coarser forms of waste wood is discussed by B. B. Fogler ("Utilization of Wood Wastes in Chemical Industries," Arthur D. Little, Inc., Cambridge, Mass.).

Disposing of Bark

Waste bark has been employed in a variety of ways. The barks of chestnut oak, tan oak and hemlock are used in the manufacture of tanning extracts. The extracted chestnut bark has been employed for paper. Bark is now used for paper of a certain type, roofing felt for asbestos shingles, white lead by the Dutch process, insulating material, and a sound deadener to some extent. It is reported that ground bark is used as a substitute for wood flour, while that from Douglas fir can probably be substituted for ground cork.

Disposal by Utilization In the Pulp Industry

By
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REDUCTION of stream pollution from wastes involves first, recovery and utilization of the waste to the fullest extent possible within practical limitations, and second, treatment and disposal of residual wastes. In many instances the former will result in a substantial financial return to the industry. In others the recovery itself may not be profitable, but may furnish the most practical and economical method of disposal.

The problem of the pulp and paper industry may be almost, if not completely, solved by recovery and utilization. The recovery of certain wastes will yield a substantial financial return, but in other cases it will only furnish a practical method of disposal with little or no return and possibly a deficit. Considerable research and study in connection with certain methods, however, is yet necessary. Hence this discussion will be devoted wholly to the problem of utilization, rather than to consideration of methods of treatment or disposal.

In general, pulp and paper mill wastes are included in two types of pollution, viz: suspended matter, resulting in sludge deposits that may cause unsightly conditions and interfere with the spawn or spawning of fish; and organic matter, which causes a reduction of the dissolved oxygen of the stream. There is no indication of toxic or poisonous substances in concentrations normally found present, nor is there the health hazard as with domestic sewage. Interference with water purification processes, however, may indirectly affect public health.

The suspended matter in pulp and paper mill wastes consists largely of stock losses that may be recovered and utilized to the financial advantage of the industry, while the organic matter is more intimately associated with pulping processes, where recovery and utilization is of questionable value to the industry.

White Water Discharges

Under this classification is included all stock loss, such as fiber, clay, size, color, and other materials that go into the finished sheet of paper. The oxygen demand of this water is low but it contains a large part of the suspended matter referred to above. White water is a general term used in the industry to cover all waste water used in washing the pulp and in processing and preparing the fiber and other raw materials to form "stock" for the finished product. Water is the carriage vehicle used to convey the stock through the system onto the paper machine, where the water is removed in the formation of the sheet. The waste water or "white water" from the machine carries with it considerable valuable stock, which in the early development of the industry was wasted into the streams but is now being recovered and returned to the sheet in the more progressive mills.

A survey of the pulp and paper industry of the United States by the writer in 1928 indicated an annual net saving of $5,261,615 annually in fiber utilization, but a potential loss of $6,389,167. The profits and losses in the various grades or classifications are indicated on p. 546. While marked improvements have been made since, a personal survey of 50 mills in 1930 by the writer indicates that a net saving of $1,000,000 annually could be made in them by more complete white water utilization. These figures are based only on the recovered fiber. There are, however, additional savings, including other raw materials, water, and heat. A few typical instances may be cited as follows:

$130,000 annually is being saved with an installation expenditure of $41,000 by a mill manufacturing 100 tons of paper daily.

$600 monthly is saved by a board mill purchasing water from a municipality by the substitution of white water for fresh water.

$75 daily in heat units and $25 in fiber recovered, is realized in another board mill.

$100 daily could be saved by a certain pulp mill purchasing water from a municipality and using 60,000 gal. per ton of product by closing its white water system as has been done in another mill manufacturing the same class and grade of pulp, but which is using only 20,000 gal. of water per ton.

The extravagant use of water and resulting white water losses is demonstrated by the fact that the water consumption in paper mills operating on the same grades varies from 1,500 to 100,000 gal. per ton of product. The relation between water consumption and white water losses is illustrated on p. 545 on which is plotted the result of surveys in 24 mills. The mill with the least water consumption, about 1,800 gal. per ton of product, had a total loss of about ½ per cent while in the mill with the highest water consumption 100,000 gal. per ton of product, the loss was 5.7 per cent.

White-Water Treatment

Satisfactory methods of white water utilization have been developed and are in use in practically all grades and branches of the industry, yet their general adoption has been slow because of fear, particularly among the finer grades, of deleterious effect upon the product, notwithstanding the fact that in many instances where the problem has been solved better qualities have resulted. "White Water Utilization" was the subject of a special report by the Waste Committee of the Technical Association of the Pulp and Paper Industry, in its proceedings for June, 1931. Space is not available in this paper for detailed discussion of methods. Utilization, however, consists essentially of the substitution of white water for fresh water wherever possible in the process. Briefly, the procedure is as follows:

1. A complete white water survey, consisting of measurements of flow, sampling and analyses of the waste white water, is first necessary to determine existing losses and the extent to which expenditures for recovery are economically feasible.

2. Fresh water consumption should be reduced to a minimum irrespective of white water utilization.

3. White water is recirculated and substituted for fresh water wherever possible throughout the mill. This may be accomplished to a considerable extent without "savealls" or other treatment of the white water.

4. In some cases "saveall" equipment, consisting of settling tanks, screens, or filters, is necessary to remove a part of the stock from the white water before recirculation. The recovered stock is returned to the product and the clarified water substituted for fresh water.

5. Application of these methods of utilization requires careful study and development in the mill. Adjustments will have to

be made in manufacturing process to compensate for paper-making materials formerly wasted but returned into the system.

6. Because white water utilization tends to stimulate biological growth causing slime troubles, sterilization with chlorine, chlorine and ammonia, or other chemicals is necessary to keep the stock clean.

Sulphite Mill Effluents

In the sulphite method of pulping wood no practical and economical utilization of the waste liquor has yet been developed. This waste, however, has the greatest oxygen demand and constitutes the most objectionable source of pollution of any from the industry. It contains 50 per cent of the dry weight of the original wood, and amounts to about 2,000 gal. per ton of finished pulp. The sulphite pulp production in the United States for 1930 was 1,628,000 tons.

The wealth in this waste has stimulated chemists and engineers to extensive research, so that between 700 and 800 patents have been issued for its utilization. While many products may be manufactured from sulphite waste liquor, the cost is so great or the demand for the product so limited as to be economically impractical in most cases. One company alone has spent over a million dollars in research on this particular problem, and is now recovering the waste liquor from one of its mills because of a critical condition regarding stream pollution. The deficit in this recovery, however, is said to be $12,000 to $15,000 a month. Another mill spent some $200,000 for an installation to utilize sulphite waste liquor, but the plant proved a failure and had to be abandoned. The numerous failures have created a cautious attitude on the part of the industry in regard to this problem, but the agitation regarding stream pollution is stimulating further research and studies to develop a satisfactory method of disposal.

The more recent developments in sulphite waste liquor utilization follow.

Concentrating Liquors

Utilization involves evaporation to concentrate the waste liquor as an initial step in most methods. Because of the corrosive properties of the waste this has been a difficult problem, but has been solved in some cases by neutralization of the liquor, and in others by the use of special alloy metals in the evaporators.

The "Robson" process which is controlled by the West Virginia Pulp & Paper Co., depends initially on evaporation. The residue is converted into a tanning extract, core binder for foundry work, and is also used for briquetting coal. This method of utilization is being used at Ausable Forks, N. Y., the West Virginia Pulp & Paper Co., Covington, Va., and Hammermill Paper Co., Erie, Pa. Due to the limited demand for the manufactured materials, however, the process is not being extended to other mills.

One of the more recent developments in evaporation indicates the feasibility of evaporating under pressure, and utilization of the steam produced in the sulphite digesters. This recovers a part of the SO_2 back into the process. Theoretically the economy of this method appears feasible.

The residue after evaporation may be used as a boiler fuel, which has a fuel value of more than enough to evaporate the liquor, so that some value is realized in its recovery. A particular advantage of this method of utilization is that the recovered material is used in the industry itself where there is ample demand for it. Difficulties are encountered, however, in burning the residue because of deleterious effect on the furnaces.

From the economic standpoint it appears that evaporation and burning is feasible with a coal cost of $6.00-$6.50 a ton. With the value of coal less, a deficit will result from this method of utilization.

Fermentation Processes

Sulphite waste liquor may be converted into alcohol by fermentation. The yield, however, is relatively small, and the residual liquor is not appreciably improved from the standpoint of stream pollution. Several plants in Sweden were manufacturing alcohol a few years ago, but it is understood that this process has been practically abandoned. It has been tried in one or two plants in the United States but found impractical.

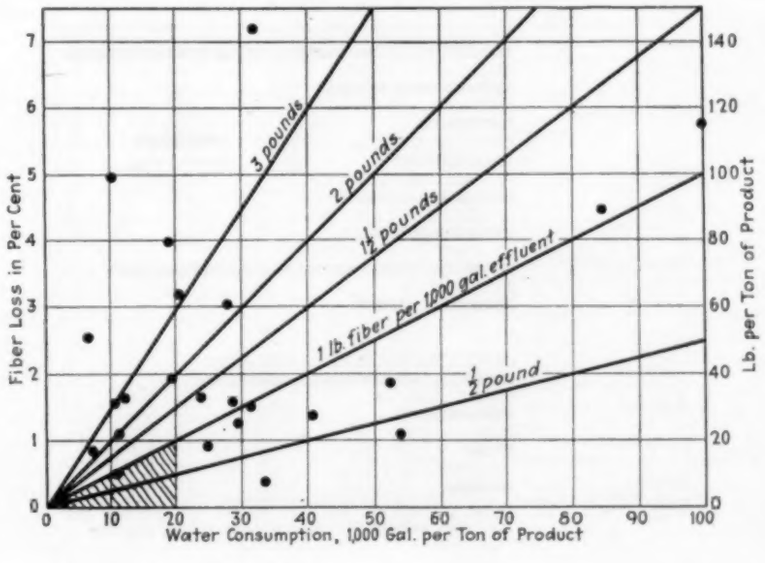
A recent patent has been taken out for the manufacture of baker's yeast from sulphite waste liquor. It is claimed that yeast may be made in the United States by this process for about three cents a pound. A plant to produce 10,000,000 lb. of yeast a year would require an investment of about $300,000. The yield is said to be 200 to 300 lb. of yeast per ton of waste. On this basis, therefore, the sulphite waste liquor from the mills of the United States would produce between 400 and 500 million lb. of yeast yearly. This would seem a tremendous amount of material, hence a general application of this method to the industry is impractical. Furthermore, it is probable that this process, similar to that of manufacture of alcohol will not materially improve the wastes as regards stream pollution.

Precipitation of Solids

The Howard process, a recent development, consists of differential precipitation. In the first stage calcium sulphite is thrown down, recovered, and utilized back into the process. In the second reaction the lignins, resins, and other organic materials are precipitated. These may be recovered and burned as a boiler fuel or additional byproducts may be manufactured from them. This process has been carried through the pilot stage, but no commercial plant is yet in operation. Indications are that, with coal at $6.00 to $6.50 a ton, a small profit may be realized by this method. Plans are being developed for a commercial installation at Marathon Paper Mills Co., Rothschild, Wis. The process will utilize about 95 per cent of the total sulphite waste liquor, and result in an over-all reduction of oxygen demand of about 80 per cent.

There is also the possibility of developing a sulphite process with a soda instead of a calcium base. Research has been conducted on this problem by the United States Forest Products Laboratory. Their studies indicate that the soda base produces a better yield and a stronger pulp that is more easily bleached. No work has been done, however, on the recovery process that will be necessary to make this method economically feasible. Certain individ-

Water Consumption and Profit Losses in Pulp and Paper Industry. Only Two Plants Actually Operated in Optimum Shaded Area



ual companies are also endeavoring to develop this method.

Sulphate and Soda Processes

In the sulphate and soda processes of pulping wood the residual liquor is recovered and utilized back into the process. This is necessary to place the method on an economical basis, and is possible because the recovery is more simple than with the sulphite process. The only waste liquor entering the stream, therefore, is that carried away with the final washing of the pulp, and should not exceed 10 or 15 per cent of the total liquor or 200 to 300 gal. per ton of product as compared with 2,000 gal. in the sulphite process.

Reduction of pollution from these wastes consists primarily in developing improved methods of reclaiming the liquor and washing the pulp so that a minimum of the waste is discharged into the stream with the final wash-water. This is accomplished by reusing the weaker wash water for the first washing of the pulp so as to build up the concentration for evaporation. Special methods of washing may also be adopted.

In the sulphate process there is produced a lime sludge which may constitute an objectionable source of pollution. In some mills this is being utilized by the farmers in the vicinity as fertilizer. It is feasible, however, to reclaim, reburn, and causticize this lime and use it back into the process. In certain sections of the country this is not economical because of the low cost of lime, but on the Pacific Coast where the cost of lime is relatively high it is general practice.

Strawboard Mills

In strawboard mills the straw is softened to a pulp by cooking with a lime or soda solution. This cooking liquor is carried with the wash water into the stream. No practical method of complete utilization has yet been developed. By revised methods of washing and utilization of white water, one mill has reduced its volume of waste from about 950,000 gal. daily to 530,000 and the suspended solids from 31,500 lb. to 15,000. Another mill has reduced its volume of waste from 24,000 to 10,000 gal. per hour.

Some research has been done regarding treatment of this waste to precipitate certain of the constituencies and thus retain the whole value of the straw in the board. The results, however, have invariably indicated an inferior quality of material. Further research is essential in the waste problem of strawboard mills.

Dirt Removal Problems

Utilization of wastes in paperboard mills consists primarily of white water utilization. In some of the higher grade mills, however, the old papers contain a certain amount of dirt that must be washed out and disposed of.

In the manufacture of book paper from old magazine stock a de-inking process is necessary to remove the ink from the old papers. This produces a peculiar waste for which no satisfactory use has yet been developed. This waste material consists of about 25 per cent fiber and 75 per cent clay. In some mills where a dark colored board is manufactured, the reclaimed wastes may be utilized to a certain extent in the board. Where only high grade papers are made, however, this is not feasible. There is a possibility of manufacturing a filler or fire board for building material. Molded articles may also be made from the recovered waste. Practical utilization, however, has not yet been developed.

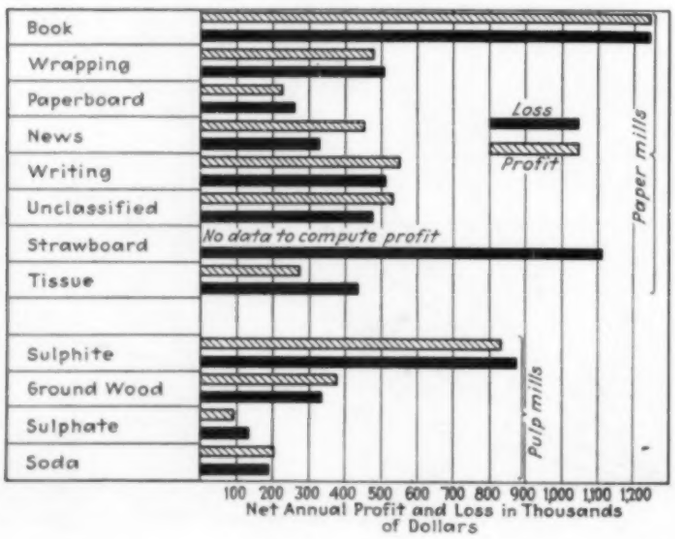
Pulping of old rags produces certain dirt or waste in the washing and conditioning of the rags, the recovery and utilization of which does not appear feasible. Furthermore, there are certain cooking liquors to dispose of in connection with this process. Primarily, however, waste utilization in rag mills consists of white water utilization.

General Status of Disposal

In general the problem of waste utilization in the pulp and paper industry may be summarized as follows:

1. White water utilization promises the greatest return to the industry, $5,000,000 to $6,000,000 annually.
2. While sulphite waste liquor contains 50 per cent of the dry weight of the wood and constitutes the most objectionable source of stream pollution, utilization does not appear economically feasible to the industry at the present time, although it may furnish the most practical method of disposal.
3. Research is particularly needed regarding the utilization of straw board mill wastes and the wastes from the de-inking of old papers.

Profit and Loss in Fiber Utilization in Various Pulp and Paper Industries



Tin-Bearing Wastes From Weighting

By VICTOR FROELICHER
Director of Research
Textile Dyeing & Printing Co. of America, Hawthorne, N. J.

MOST commercial grades of silk are weighted with tin salts by immersion of the degummed fibers in a solution of tin tetrachloride. In the silk washing operation which follows, the tin is precipitated upon the fibers in the form of tin hydroxide and the excess tin-bearing solution is carried away in the wash water.

Silk weighting establishments use large volumes of water for washing purposes. The possibility of polluting adjacent streams demands that these acidic wastes be neutralized and economic considerations dictate the recovery of the valuable tin salts, both soluble and insoluble. When recovered in compact form, these salts may be resold to the manufacturers of the weighting chemicals and thus made to yield a handsome revenue which pays back the cost of recovery several-fold.

Standard recovery practice in this industry used to consist of treating the tin-bearing solution with lime for neutralization of the acid and then passing through one or more of a series of hopper-bottomed, concrete settling tanks for the precipitation of the tin hydrates and oxides. A relatively tin-free and neutral solution overflowed from these tanks to the sewer or river and

periodically one or more tanks would be withdrawn from service so that the precipitate might be withdrawn for filtration on plate and frame presses and drying in coal-heated tunnel driers.

More up-to-date recovery plants, such as the one at the Hawthorne, N. J., works of Textile Dyeing and Printing Co. of America, utilize modern continuously-operated equipment throughout and employ close chemical control of all operations. Reduced labor costs, higher recoveries, less fuel consumption and greater reliability adequately justify the pains taken in the design and operation of the tin waste treatment plant.

The rate of flow of tin-bearing waste water, in the case cited, averages 1,600 gal. per min., contains, at times, as much as 90 mg. per lit. of tin salts and a few hundredths of one per cent free hydrochloric acid. Small as is the concentration of the tin salts in the wash water, their value will average about $150 a day, based on capacity operation of the weighting department and pure tin quoted at 30c. a pound.

At this plant the tin-bearing wastes are neutralized by the addition of a milk of lime slurry, continuously added from an agitating tank controlled by routine chemical analyses of the final discharge to the river. The neutralized water then flows through a concrete tank, 70 ft. square, equipped with a Dorr clarifier mechanism for the collection of the precipitated tin salts and a diaphragm pump for the removal of the salts and their feeding to a storage tank.

The dryer used is of the spray type, designed and developed by Industrial Associates, Inc., of New York. The sludge fed to the spray dryer contains about 95 per cent moisture and is reduced to a moisture content of about 10 per cent by being sprayed through a high speed centrifugal atomizer into a chamber through which hot air is continuously forced. The instantaneously dried tin salts fall to the bottom of the drying chamber and are discharged directly into shipping containers on the floor below.

The complete tin recovery plant at Hawthorne operates continuously. The effluent from the clarifier is either neutral or slightly alkaline and contains about two or three mg. of tin salts per liter, corresponding to a tin recovery of 97 to 98 per cent. This modern mechanically-operated plant occupies much less space than its intermittent manually-operated predecessor and costs about one third as much to operate.

How a Textile Mill Purged Its Effluents

By
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SUCCESSFUL disposal of trade wastes may be illustrated by the example of a plant engaged in the mercerizing, bleaching and dyeing of cotton materials. The work extended throughout a period of several years, during which the treated effluent was under constant surveillance of local city authorities. Inasmuch as the operations were conducted within the locality under the direct supervision of the Passaic Valley Sewerage Commissioners, this organization took a deep interest in the character of the methods.

The work was carried out in a plant which, at that time, had no sewage disposal facilities, and the only means of disposing of the trade waste was to so treat it, that it could be discharged into a small brook which flowed through the property. It was recognized that in discharging into this brook, the waste must be neutral, water-white, and free from suspended matter. It was further recognized that the "oxygen content" of the brook water must not be impaired, lest the plant and animal life, which abounded, would suffer.

The fact that the disposal was to be carried out at a new plant, which at the beginning of the operations was not wholly completed, gave an opportunity to study the various phases, at first singly and later in combination, as the different sections of the plant began operations. Prior to the time of starting the new plant, it had been impossible to visualize the character of the composite wastes as the various sections of the old plant were too widely separated to make such a collection feasible.

Two 200,000-gal. tanks, which could be used singly or in combination, were installed for holding the raw waste, the contents of either one of these tanks being discharged for treatment while the other was being filled. The character of the liquor contained in the tanks was determined by chemical means, in order to determine the proper dosage to prepare it for disposal.

Bleach House Waste

The bleach house was the first unit completed and hence, for some time, we had opportunity to study the character of the trade waste from this section. The waste consisted of (1) dark brown liquors from the kiers boiled with caustic soda, containing the gums, pectins, and albuminous matter from the cotton; (2) wash waters from the calcium or sodium hypochlorite bleach treatment; (3) wash waters from the sour (H_2SO_4) treatment; and (4) the extracted soap and tinting solutions from the finishing operations. While early observations seemed to indicate that the eventual composite would be dark brown in color, it was found that the dilution, caused by the wash waters and the presence of chlorine from the bleach, gave a solution comparatively light in color.

The chemical treatment finally selected, consisted in the addition of hydrated lime and aluminum sulphate, added in such amounts as to produce aluminum hydroxide just heavy enough to entangle the organic and coloring matters and produce a "flock" which would quickly precipitate. The apparatus used was the Dorr Clarifier, with a rated capacity of 50,000 gal. per hour. The raw waste solution fed by gravity through a sluiceway from the storage tanks, and received the alum and lime dosage, being baffled sufficiently for proper mixing before entering settling basin.

The original design of the clarifier called for mixing of waste and coagulating chemicals in a central well, but this was later changed by blocking off the edge of one-quarter segment of the tank, nearest the feeders, entering the treated waste in this section, and allowing to travel directly across the tank before discharging the clear liquor over the periphery. The adoption of this method improved the control of the treatment so that a sample of waste, removed one-quarter minute after dosage, proved a reliable index of the entire treatment. The slowly revolving arms in the bottom of the settling basin caused the sludge to be drawn to the bottom of the central well, whence it was removed by a suction pump.

Mercerizing Plant Waste

The second unit to be put in operation was the mercerizing plant, where no trouble had been anticipated, as the waste consisted entirely of caustic soda, washed from the material after mercerizing. What actually did cause trouble, however, was the large amount of caustic soda (about 1,500 lb. per day) to be disposed of. The alum treatment, used with such success on the bleach-house effluent only, when increased sufficiently to neutralize the caustic soda, produced such a tremendous volume of sludge that the entire settling basin was filled,

allowing no room for settling. In order to overcome this condition we added H_2SO_4 from carboys, and in spite of the expense had to continue this treatment until a large iron tank, capable of holding 20 tons of 66 deg. Bé. acid had been installed. The acid was then fed, by gravity, to the raw waste entering the collection tanks, and thus we were able to again produce, as desired, a practically neutral raw waste.

The third, and last, unit to be installed was the dyehouse. While it had been anticipated that the waste from this section would cause most trouble, we were agreeably surprised to observe that the dilution, caused by the other wastes, gave an extremely light-colored solution, and one which responded readily to the regular treatment, which had, by that time, become quite well standardized. Some trouble was experienced in the use of certain dyes, such as the naphthols and basic colors, which, at first, were allowed to enter the raw waste, thus allowing a relatively small amount of color to contaminate a large volume of waste, the subsequent removal of color presenting very real difficulty. It was quickly observed, however, that by chemically destroying the color from the concentrated dye bath, in special cases before it entered the raw waste, all trouble was avoided.

Process Water Treatment

The process water was obtained from a brook, and possessed such a degree of hardness, due to calcium and magnesium salts, that it was necessary to give a zeolite treatment in order to properly soften it. The zeolite beds naturally required a regenerating treatment with sodium chloride, which in turn had to be disposed of. Owing to the high amount of magnesium chloride in the wash waters from the zeolite regeneration, we could not discharge this directly to the stream, but fed it into a large sump outside the filter and softening house. There it was treated with a very strong solution of caustic soda in order to produce insoluble magnesium hydroxide, the supernatent liquor thereafter being discharged directly to the brook. The sludge is subsequently removed to waste land when the sump becomes too full for operation. During the early treatment of the trade waste, the disposal of $Al(OH)_3$ sludge, presented a serious problem, but it was eventually found that by spreading it upon unused land, it became readily agglomerated with the earth.

The necessity for treatment with new caustic soda was eventually overcome by piping the waste to the central collection tanks and allowing the waste caustic soda from the mercerizing plant to accomplish this work, thus again materially reducing costs. Throughout the entire time that the treated effluent was being discharged into the brook, the oxygen content of the water was normal, although at times it had to be stimulated somewhat by aeration, this being brought about by a system of spray pipes.

The cost of the process was high owing to the large volume of waste which required treatment, this often amounting to 500,000 gal. per day. If several plants, located in the same area, could treat their wastes jointly, it would mean a lower labor cost, and it is quite probable that the waste from one plant would counteract that from another, thus reducing chemical charges.

Tanneries Cope with Putrescible Discharges

EDITORIAL STAFF

IN COMMON with the rest of industry, the tanner is under the necessity of disposing of waste products and, when possible, deriving revenue from them. But in addition, his position is more difficult than that of the majority of manufacturers in that his waste materials are largely putrescible and very easily cause nuisance and pollution.

Tannery wastes fall roughly into classifications of wet and dry solids, suspensions and liquids. Thoroughly dry waste materials which have been tanned are unlikely to putrefy, but all other waste and effluent materials are subject to this action. Considerable thought must, therefore, be given by the tanner to disposal methods which will neither make him unpopular in his community nor put him afoul of nuisance regulations.

In general, the tanner collects his solid wastes and segregates them by types wherever possible. Solids which are too small to be collected in this manner are discharged with the liquid wastes into the collecting sewer. Before the liquids and their suspended solids may be discharged to the municipal sewers or into streams, some treatment is generally required to separate and dispose of putrescible or otherwise offensive material.

Exploiting Solid Wastes

Most of the solids and semi-solids other than very fine particles are recoverable as byproducts. The untanned materials including fleshings, trimmings and limed pieces are utilized as glue stock and yield the tanner a small net revenue. In the case of sheep fleshings, the grease content is of value rather than the gelatin yield. Trimmings and otherwise unusable bits of tanned leather cannot, of course, be used for the manufacture of glue. Such wastes are collected and digested with sulphuric acid for making a fertilizer ingredient. Larger trimmings of tanned leather are used for the manufacture of small articles such as pocket-books and key containers. Still smaller pieces may be ground up and used for imitation leather, rubber goods and other products in which it is desired to secure some of the characteristics of leather.

Other byproducts obtained directly from the hide are also of value. Hair removed by the liming process is useful in making felts, insulating materials, and so on. Short hair, or hair removed by the use of sodium sulphide has no value except as a material for fertilizer. In special cases wool may be recovered from shearlings or wool skins. Grease recovered directly in the pressing of sheepskins is utilized for soap stock.

Solid residues remaining after the extraction of vegetable tannins can be used in the manufacture of chip board where the quantity is sufficient and location of the tannery is suitable. In other cases, such residues are partially dewatered and burned under the boilers.

Voluminous Liquid Discharge

Liquid wastes constitute a more serious disposal problem in the tannery. Very large quantities of water are necessarily used in the production of leather. As a result, in larger tanneries, the daily volume of sewage will often run from ½ to 1 million gallons per day. With such a considerable flow, it is obvious that relatively large quantities of suspended or dissolved materials may be carried from the plant without any serious concentration in the effluent.

Liquid effluents represent a considerable diversity of solutions and suspensions. Among them are soak water containing salts, suspended dirt or sand; sodium sulphide solutions; lime suspensions and solutions; dilute ammonium chloride and brine liquors from bating; spent tan and coloring liquors and fat-liquoring emulsions, usually carrying dilute sodium sulphate; and finally vegetable tan liquors. Depending on the circumstances, any or all of these various components may be present in varying proportions in the sewage at different times. Most of the components are soluble and relatively innocuous. On the other hand, in some cases, precipitation of calcium and other salts will occur. Another problem is encountered where there are many tanneries in a single community, in which case tannery effluents dominate the industrial wastes, and the lime may result in scale formation in the city sewers. In one such instance, prevention of this scaling

required neutralization of the alkalinity before the sewage could be admitted to the municipal lines.

Suspended solids in the sewage will ordinarily have to be removed before the liquids can be discharged into the city sewers or other agencies of disposal. Most plants are equipped with general collecting sewer lines of adequate size so that they are not readily blocked. They are usually provided with sumps or catch basins to collect heavy solids which are removed periodically. Lighter solids, however, fine enough to remain in suspension, are not separated by any such simple treatment. Filter beds, settling basins, thickeners, filters, screens and save-alls, with or without chemical treatment to assist flocculation, must therefore be used.

Where large areas are available, filter beds are sometimes used. In addition to the large amount of space required, this method is likely to prove unsatisfactory because of the difficulty in disposing of the solids which are deposited on the beds. These solids may become very objectionable in the open air and must eventually be covered with cinders or dirt or removed by rather expensive procedure.

Settling basins are generally a more satisfactory solution. Sewage is led into the basin where the greatly increased cross-section reduces the velocity of flow to a point where the solids will settle. The solids can then be removed by conveyors, plunger pumps or intermittently by draining the beds and forking or conveying the sludge into trucks. In the last method, two or more beds are operated alternately. In any case, the clarified effluent can be discharged directly into a stream or sewer or given a further chemical treatment if that should prove necessary. A somewhat similar method of removing solids is through the use of thickeners of the Dorr or some other type. Such apparatus facilitates control and sludge removal.

Pneumatic save-alls, screens and vacuum filters may be used successfully in obtaining a sludge of about 20 per cent solids. This is desirable where transportation of a considerable quantity of water in the disposal of the thickened solids is out of the question.

Further Separation Methods

An interesting screen, made by the Sanitary Corp. is used in certain tanneries. This consists of an inclined circular screen constructed of brass plate perforated with small holes. This screen is placed in the flow channel so that clear sewage can flow through the perforations while the solids are retained on the plate. These solids are collected by rotating brushes and are discharged into a hopper for removal by truck.

Chemical treatment is often of assistance in dewatering and settling solids, or a necessity in the control of pH of tannery waste. The materials used are generally aluminum sulphate or sulphuric acid. In most tanneries, however, in view of the very large amount of water to be treated, the cost of chemical flocculation and pH adjustment is so high as to be almost prohibitive. In the case previously mentioned where lime in the effluent from a number of tanneries resulted in scale within the city sewers, it was found that treatment with carbon dioxide from flue gases could be used to precipitate the lime as calcium carbonate. It was, of course, necessary to avoid the formation of the soluble bicarbonate.

Amelioration of Packing-House Waste

By ANTHONY J. FISCHER
Development Engineer
The Dorr Co.
New York

UNTIL recently, standard practice has dictated, first, removal of paunch and stock yard manure and, second, the treatment of the remaining sewage by one of such methods as the plain-sedimentation, septic-tank treatment or the use of the activated sludge process or sprinkling filters. None of these established methods attempts to recover the proteins which are destroyed by the bacterial action.

As a result of a research program recently completed by Prof. H. O. Halvorson of the University of Minnesota and W. J. Fullen, chemist of the George A. Hormel Co., a distinctly new type of chlorination process has been put into operation at this company's plant at Austin, Minn. In addition to removing more than 70 per cent of the nitrogen and 98 per cent of the suspended solids and securing a substantial reduction in B.O.D. (biological oxygen demand) the process recovers the proteins in dry form.

The plant now treats a maximum of 750,000 gal. of sewage per day as experience has shown that a strengthening of the waste, by eliminating condenser water, etc., materially improves treatment and reduces the amount of chlorine required in the subsequent treatment process. After preliminary removal of paunch and stock yard manure, the waste is passed through a presedimentation tank 45 ft. square, equipped with a clarifier mechanism, for the removal of the heavy, quickly settling solids.

The partially clarified effluent from this presedimentation tank flows through two series-connected tanks 15 ft. square, equipped with draft-tube agitators, and providing one hour's theoretical detention. Into the first of these mixing tanks, chlorine gas is introduced through Duriron injectors. Liquid chlorine is received in ton containers and its rate of flow from these containers is measured by a vacuum gage on the line leading to the injectors.

The chlorinated sewage next flows into a final settling tank 70 ft. square equipped with a clarifier mechanism for the final removal of suspended solids. The clear effluent overflows into the river, the settled solids are removed by a pump and floating scum is mechanically skimmed to one side of the tank and recirculated through the mixing tanks until it finally sinks, to be withdrawn with the other solids.

The sludge is pumped from the primary and secondary settling tanks, treated with ferric chloride alone or with lime as conditioning agent, and dewatered separately to an average of about 75 per cent moisture on a Dorrco vacuum filter. The filter cake is dried in the same type of rotary drier used for handling tankage, and the dried product is ground to fine size. The George A. Hormel Co. is now conducting further experiments on the finished product, looking toward its marketing as a stock feed or rendering it sufficiently free of fats so that it may be used as a nitrogenous fertilizer.

As a means of greatly reducing pollution the process has been successful. The evolution of obnoxious gases, the presence of floating solids and the cloudy appearance of the river have completely disappeared and the presence of not more than 0.06 p.p.m. of chlorine in the river water at a point of a few hundred feet below the plant cannot fail to have a generally beneficial effect.

Treating Plant of George A. Hormel Co., Described Above

Extraction of Brines From Petroleum

Profitable Oil Wells Are Often Found Near the Ocean; Sometimes Actually In It. In This Article the Special Attendent Difficulties Are Discussed

BRINES from producing gas and oil wells, together with the waste solutions from drilling operations, have been the bugbear of oil operators in various fields. This problem was a particularly pressing one in the southern California fields, because of the close proximity of these fields to bathing beaches and because of the cities located on the ocean shore. When the saline solutions were allowed to run over agricultural land, crops were ruined and the land was rendered unfit for crops for some time. Storage of the waters in reservoirs to reduce the volume through evaporation raised the salt content of the underground water, thus rendering it unfit for irrigation.

Cooperation of the producers in the southern California section brought about a solution of the problem and resulted in the establishment of a plant for handling waste oil-well brines in 1928. This venture is being handled by the Sante Fe Springs Waste Water Disposal Co., which now numbers 35 operators among its members.

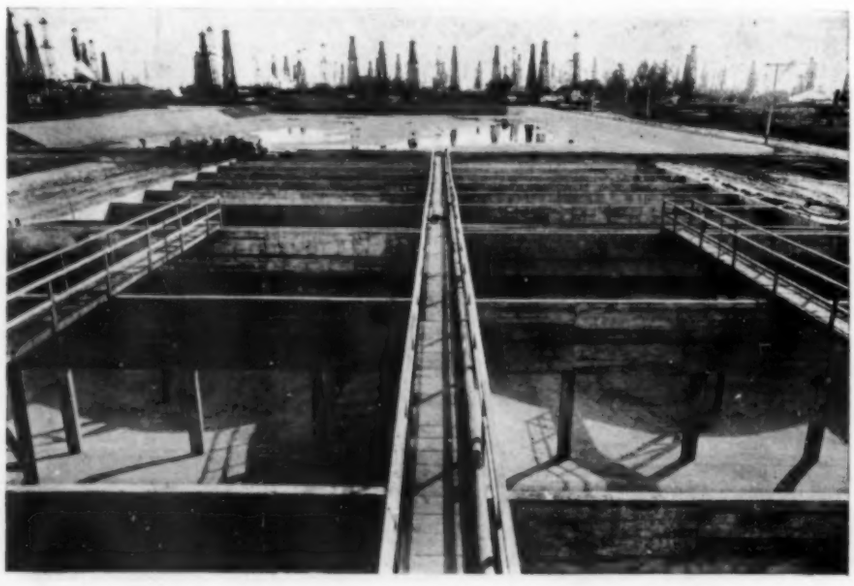
The process used was experimentally developed through pilot-plant operation. After floating oil is removed, the water is passed over a series of riffles. The separation of the oil present as an emulsion is by far the most difficult part of the process. This oil amounts to less than half of the total oil. After passing over the riffles, in the process of which aeration is carried out, the water enters compartments so designed that it moves with a low velocity. Oil particles rise to the surface and break into a thin film which builds thicker until it can be skimmed off.

Gravity flow is used entirely. The water entering the plant is aerated, settled, floating oil removed by skimming, and is again aerated as it passes over the riffles. A second skimming then removes oil released by breaking the emulsion. The water is then passed through an excelsior filter and discharged to the ocean. During 1930, the salt water discharged to the ocean from the entire operations amounted to 24,133,973 bbl. with an average oil content of 5.11 part per million. The net quantity passing through the plant was 21,240,279 bbl. The cost of the entire operations amounted to 1.8 mills per barrel. The recovered oil sold amounted to 80,409 bbl. at an average price of $0.546 per barrel, thus making the entire net cost of operation for the year less than $300.

At the present time 35 operators are using the system. The water is metered from each source, there being 68 meters. The total investment in the system, including the office building, is about $489,000. The area covered includes the following fields: Montebello, Murphy-Whittier, Santa Fe Springs, and West Coyote. The discharge line running to the ocean, a distance of about 15 miles, is made of vitrified clay pipe.

In spite of the fact that the plant is handling much more waste brine than was anticipated in the design, it is operating very satisfactorily and efficiently.

Plant on Oil Fields of Southern California for Separation of Brines From Petroleum



Profitable Fertilizer From City Sewage

By G. K. HOOPER
City Engineer
Pasadena, Calif.

AN UNUSUAL and profitable example of conservation, combined with a real disposition of sewage, has been attained by the city of Pasadena, Calif., in converting this substance to a valuable and inoffensive fertilizer. Situated as the plant is, in the midst of a rapidly growing residence locality, no nuisance from operation could be tolerated; and the city-owned land upon which the plant is located was considered too valuable for use in sludge disposal, either by burial or air drying.

Recognizing the agricultural value of the nitrogenous and other compounds composing the sludge and the large potential market awaiting such a product, a simple process was worked out by the plant organization under the direction of A. W. Wyman, plant superintendent, which not only produces successfully and without nuisance a marketable product of real value, but which has proved to be the least expensive method of disposal available.

Processing Sludge

This plant operates on the "Activated Sludge" process. The excess sludge not needed for activation and amounting to about 70 per cent of that produced, is withdrawn periodically from the process and led to coagulation and storage tanks in which are added the coagulating reagents which prepare the material for de-watering. While in these tanks, the sludge is aerated to prevent both settlement and septic action. The coagulated sludge next flows by gravity to mechanical filters, which reduce its moisture content from over 99½ to a little under 80 per cent, removing thus a great bulk of the contained water. The filters, three in number, are of the rotary vacuum type.

At a suitable point in the revolution of the filter drum the vacuum is momentarily interrupted and the "cake" drops from the cloth onto conveyors which carry it to the dryer house. Here the "cake" is reduced to a somewhat granular form containing about 5 per cent moisture, by exposure to heat in a double-shell revolving dryer, fired by natural gas. The "cake" is tumbled over and over in the annular space between the shells, out of contact with the flame during the revolution of the dryer. Suitable shelves attached to the dryer shell lift the contained material and cascade it through the hot gases onto the surface of the inner

shell. The products of combustion return through the annular space and further dry the contents by direct contact.

As the material tends to form lumps or "balls" in its course through the dryer, it is next rough screened and the damp lumps or balls are returned to the entrance to pass again through the heat. The final product is next reduced to market size and dropped into bins, from which it is drawn into clean sacks containing 100 lb. each. The steam and gases liberated during the drying are led to an incinerator, in which they are rendered inoffensive and discharged into the atmosphere at such a height that their dilution can cause no nuisance.

Fertilizer Value

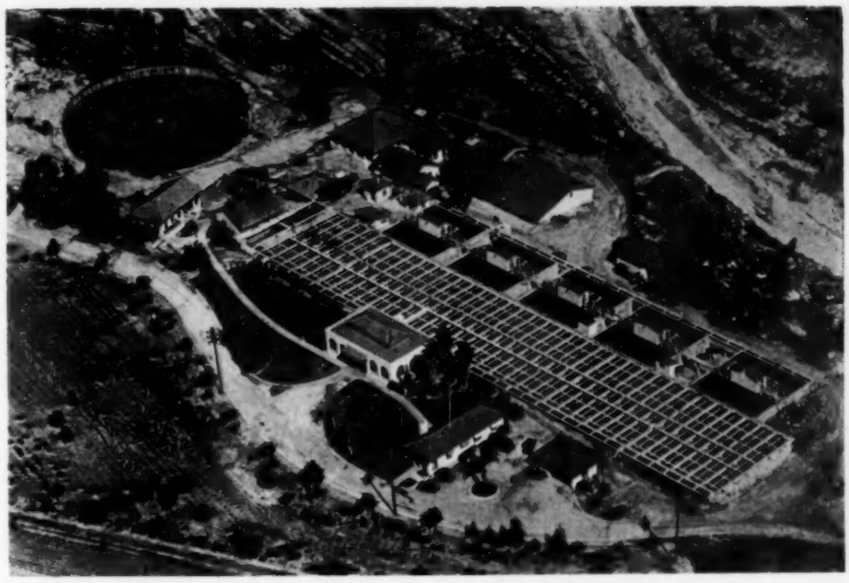
It is sold at the market price for its available fertilization material and previous to the agricultural slump, brought in sufficient revenue to meet practically the entire labor cost of the complete disposal. The present return is a little more than 85 per cent of that amount. The analysis of the final product by state authorities is as follows:

Nitrogen total	5.25 per cent
Nitrogen, expressed as ammonia (caculated)	6.07
Phosphoric acid, available	2.00
Phosphoric acid, total	2.73
Potash	0.30
Organic matter	69.92
Boron	Negligible

The fertilizer is practically odorless and entirely sterile, no evidence of infection or of occupational disease having shown itself in the five or more years during which the process has been in use. It is readily taken up by the soil with practically none of the disagreeable appearance and odor of other materials.

The production is approximately 3,000 tons per annum, that is, about 50 lb. per unit of population served, or about one ton of dried fertilizer per million gallons of sewage treated.

The plant is maintained as a public park and all who see it for the first time express their surprise and gratification that such a process can be conducted without disagreeable features. The State Board of Health has reported that the effluent from this plant is purer than the water of the stream into which it is discharged. It serves the four adjacent cities of Pasadena, South Pasadena, Alhambra and San Marino and has been in operation about 7½ years. Extensions and improvements are now being installed as follows: Four additional aeration tanks, a measuring flume for incoming sewage, an improved air header embodying a Venturi throat for air measurement, and an 8,000 cu.ft. per min. rotary air compressor. An additional clarifier with improved launder design has recently been put into use.



Airplane View of Sewage Disposal Plant of City of Pasadena, With Tanks in Foreground, Clarifiers Directly Behind Them, and Other Buildings in the Rear

City Sanitation Demands Effective Garbage Disposal

EDITORIAL STAFF

GARBAGE DISPOSAL is a major problem of every urban community. That this should be the case will be readily apparent from the fact that the daily per-capita garbage production in American cities at the present ranges between 0.6 and 0.8 lb. on the wet basis. Of this weight, the solids in a typical city average about 6 per cent protein, 5 per cent fat, 15 per cent carbohydrate, and 5 per cent ash.

Which of the several available methods of garbage disposal will be most satisfactory in any given instance apparently depends on the circumstances. Sale or donation for hog feeding is a method used very satisfactory in a number of cities. Provided that the garbage will sell for not less than $0.60 per green ton, this is said by E. E. Butterfield to be the most economical proceeding. A method in favor in other localities is that of garbage reduction, a process yielding fats, fertilizer, and in one case, stock feeds as well. One authority believes that reduction is the best disposal method for cities of more than 200,000 inhabitants. The third method is incineration, which would perhaps be the ideal one were it not for the fact that green garbage will not support combustion. According to a combustion balance cited by E. E. Butterfield, the heat required for complete combustion is about 110 per cent of that available in the combustible ingredients. This is a result of the large percentage of water in all green garbage. Heating the water alone to the temperature of operation is said by Mr. Butterfield to consume about half the heat available. However, if dry refuse may be burned with the garbage, or if part of the water is removed by pressing, there may actually be a positive balance of heat from the combustion available for the generation of steam or power. This condition exists in two cities in the South. The final disposal method, fortunately, is not much practiced today. This is the dumping of garbage into sewers, streams, or at sea. New York, the outstanding offender in this respect, has recently been enjoined from dumping at sea and is now making plans for garbage incineration.

Whatever method may be best in a given case, garbage reduction holds the greatest interest for the chemical en-

Production and Power Consumption of Indianapolis Reduction Plant

Year	Green Garbage Tons	Production and Yields* Feed, Tons	Fertiliser, Tons	Grease, Lb.	Steam and Power† Steam Used Lb.x1,000	Kilowatt-Hours
1928.....	31,766.7	1,403.95	1,597.45	1,676,440	79,983	545,890
		88.4	*100.6*	*52.8*	*2.518*	*17.2*
1929.....	30,315	1,050.10	1,864.15	1,809,810	83,201	579,000
		69.3	*123.0*	*59.7*	*2.744*	*19.0*
1930.....	27,140.1	688.10	1,844.28	1,666,000	71,821	509,500
		50.7	*135.9*	*61.4*	*2.646*	*18.8*

* Italic figures represent yields in pounds per ton of green garbage.
† Italic figures represent steam and power per ton of green garbage.

Operating Costs in Dollars Per Ton of Green Garbage

Year	Labor	Materials and Supplies	Power	Offices, Grounds and Tracks, Laboratory	Total	Interest and Depreciation*	Total
1928.....	1.32	0.42	1.46	0.30	3.50	2.49	5.99
1929.....	1.40	0.47	1.40	0.39	3.66	2.61	6.27
1930.....	1.53	0.68	1.47	0.30	3.98	2.92	6.90

* Not included in plant operating-cost figures.

gineer. Because the municipal plant at Indianapolis, Ind., carries the reduction process farther than any other plant now operating, it is likewise the best example for description here. The plant was erected and put into operation in June, 1927, by the Board of Sanitary Commissioners of the city. Since that time it has operated very satisfactorily, both from the financial and the disposal standpoints. Disregarding the cost of collection, interest on the investment, and depreciation, items which are not taken into account in arriving at the plant's operating costs, the total profit for the two years 1928 and 1929 amounted to more than $100,000. Even deducting losses in the starting year of 1927, and the depression year, 1930, the total profit for the 3½-year period was in excess of $80,000. Although it is improbable that any private concern would show a profit, were it to undertake both collection and disposal without subsidy, the city is nevertheless—and rightfully—well pleased with the investment, since it is very unlikely that other methods could have been used at an equally low gross cost.

Operations at Indianapolis

Garbage is received at the plant in false-bottom, dump-type trailers which permit the draining of a good part of the water to the sewer. Except since 1930, when contrary to the wishes of the Board a part of the garbage was collected by hog feeders, receipts have averaged about 30,000 tons per year. Production of useful products per ton of green garbage in 1930 was 61.4 lb. of fats, 135.9 lb. of fertilizer, and 50.7 lb. of stock feeds. The last two items are to a certain extent interchangeable, so that if occasion arose, it would be possible to produce, for example, 100 lb. of fertilizer and 86 lb. of feed. Furthermore, a process developed at the plant during the past spring will increase the production of useful products more than 100 lb. per ton of green garbage.

When the garbage has been weighed into the plant it is dumped into the receiving pit, from which it is withdrawn by scraper and belt conveyors. It is raised to an elevated point, from which it discharges through gravity chutes to any one of the 32 Morrison digesters in which the garbage is cooked. The digesters are vertical, steam-jacketed steel vessels provided with heavy agitators driven from below, and with connections for live steam, decantation and venting of condensible vapors. The charge of 3½ tons of green garbage is mixed with water from a previous run and is digested under 80 lb. live-steam pressure for a period of two hours, whereupon the pressure is vented through a jet condenser and the tankage permitted to settle. After settling, the supernant tank liquor, containing part of the grease and most of the soluble materials present in the original garbage, principally carbohydrates, is drawn off to a sump. From the sump the liquor passes to a grease separator consisting of a V-bottom tank constricted at the top. As the grease overflows in the constricted portion, water is continuously withdrawn from beneath the grease by means of an adjustable inverted siphon. This water passes to a settling basin for recovery of traces of grease, after which it may be returned as make-up for a fresh digester batch; evaporated to a syrup-like material called "stick," for addition to feed; or run to the sewer.

Solids remaining in the digester must then be dried. This is accomplished by using jacket steam, agitation, and a vacuum of about 7 in. The entire drying operation takes about 6½ hr. The dried material, crude tankage, is discharged from a door in the bottom of the digester, dropping into a drag conveyor beneath the floor. From the digester building material is carried to the separation and degreasing building, where further treatment depends on the sort of feed it is desired to produce. One form, known as mixed feed, contains all of the fat remaining in the crude tankage after decantation of the tank liquor. Before it is finally sacked, this grade is mixed with the "stick" mentioned above in order to increase the nutritive value. Analysis of mixed feed is described as being not less than 16 per cent crude protein or 20 per cent crude fat, and not more than 20 per cent crude fiber. The second grade, one which has only recently been developed, is called "table scrap meal." By virtue of the fact that it has been degreased, this grade is high in protein and low in fat. It contains no "stick." Its guaranteed analysis is: not less than 21 per cent crude protein or 2 per cent crude fat, and not more than 20 per cent crude fiber.

Separating Feed and Fertilizer

When the product desired is the mixed feed, the first step after digestion and drying is the separation of the crude tankage into feed and fertilizer grades. This is accomplished in novel air separators which have been developed expressly for the processing of garbage. They consist of a revolving screen on the top of which the dried tankage is fed slowly by a small bar-and-chain conveyor. As the screen revolves, the tankage passes first under a brush which distributes it evenly, and then under a suction nozzle where the fine material is removed. From the nozzle the fines are conveyed pneumatically to a cyclone. Oversize material, which also contains bits of china, glass, and metal, continues with the screen, falling into a conveyor which carries it to the next operation, degreasing. Fines from the cyclone are conveyed to a packer, mixed with "stick," and sacked for shipment as mixed feed.

Solvent Extraction of Grease

The second feed grade, table scrap meal, is not separated from the fertilizer grade until degreasing has taken place Treatment of the crude tankage in this case, and of the oversize produced in connection with mixed feed, is identical. Either material is loaded into one of a number of percolators which are similar in construction to the digesters. The percolator is flooded with naphtha, which after 15 to 20 min. is drained off and pumped to a still. Each batch is so treated from five to ten times, with the result that the greater part of the fat is removed. This fat is then recovered by distillation and pumped to grease storage, where it joins the grease previously separated in the digestion process. The solvent is condensed and largely recovered, the losses amounting to only about ½ gal. per ton of green garbage treated. Solvent is further removed from the tankage by heating with jacket steam before the percolators are discharged. After degreasing, the tankage is removed by drag conveyors beneath the floor and transported to the air separators (if it still contains the feed grade), or to the fertilizer storage if the separation has already taken place. Fertilizer material requires only magnetic separation and grinding in a cage mill to complete it, ready for bulk shipment. Feed, if it is of the second. degreased variety, passes from the air separators to the cylone, and then to sacking without addition of "stick."

For his courtesy in explaining the process and supplying facts and figures, *Chem. & Met.* is indebted to Floyd E. Baber, superintendent of the Indianapolis reduction plant.

NEWS *of the* INDUSTRY

Chemical Engineers to Discuss Stream Pollution

A SYMPOSIUM on stream pollution and the treatment of industrial waste is to be the principal feature of the winter meeting of the American Institute of Chemical Engineers, to be held in Atlantic City, N. J., Dec. 9 to 11. Although important contributions on this subject have been presented at previous meetings of the institute, this is the first time that a major program has been developed around this theme. It is expected that this session will reveal the latest American practice and will, therefore, offer an interesting corollary to the papers read in England in December, 1930, at the conference on the Utilization of Trade Wastes, held by the Institution of Chemical Engineers.

Preliminary plans for the meeting include seven papers, to be contributed by outstanding authorities in the various fields. Prof. Thorndike Saville, of the University of North Carolina, will discuss "The Place of the State and Federal Governments in Stream Pollution Investigation and Regulation." W. L. Stevenson, chief engineer of the State Department of Health, Pennsylvania, will talk on "The Conservation of Streams by Cooperation." Robert Spurr Weston, consulting sanitary engineer of Boston, has entitled his paper, "The Use and Abuse of Streams." The work of the State Water Commission of Connecticut will be discussed by Mr. Wise, and Dr. W. Rudolfs, chief of the Department of Sewage Research of the New Jersey State Agricultural Experiment Station, will discuss "Stream Pollution in the State of New Jersey." Prof. Edward Bartow, of the State University of Iowa, has a paper on "Treatment of Specific Industrial Wastes—Starch, Glucose, and Beet Sugar." The symposium will be concluded by a summary of recent developments in the treatment of industrial wastes, presented by E. B. Besselievre, sanitary engineer of the Dorr Co., New York.

Full details of the program will be published in a later issue of *Chem. & Met.*

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Citrus Fruit Laboratory For Texas

CITRUS fruit growers of Texas will soon receive the practical assistance of the Department of Agriculture in solving their problems of utilization of citrus-fruit culls and byproducts, Dr. Henry G. Knight, Chief of the Bureau of Chemistry and Soils, announced Sept. 8. Dr. Knight said that the new citrus laboratory of the Bureau, for which funds were appropriated by the last Congress, will be established in the citrus-growing territory of the Rio Grande Valley at Weslaco, Texas, on the state-owned land of the Texas State Experiment Station.

The selection of the site was made upon recommendation of Dr. F. C. Blanck, in charge of the Food Research Division of the Bureau of Chemistry and Soils, and E. M. Chace, of the Bureau's fruit and vegetable laboratory at Los Angeles, Calif., and with the approval of Director A. B. Conner of the Texas Agricultural Experiment Station at College Station.

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National Safety Council To Meet in Chicago

DURING the week of Oct. 12 to 16, many delegates from chemical companies will meet at the Stevens Hotel in Chicago to conduct a program to consider practical ways and means for the reduction of accidents and accident costs in the chemical industry.

This accident prevention program, as an important part of the Twentieth Annual Safety Congress & Exposition, will be carried through by the Chemical Section of the National Safety Council, supplemented by the programs of the Rubber Section and the Packers and Tanners' Section. The programs of the Rubber Section and the Packers and Tanners' Section, of course, will include the consideration of other problems, but hazards from chemical operations will have an important place.

Accident experience reports from the chemical industries for the past year have been quite encouraging. For example, the 211 chemical plants which reported for 1930 to the National Safety Council showed 15.50 lost-time injuries for each million hours worked in the industry, as compared to a rate of 18.47 for all of the 28 industries which reported. The accident frequency rate(days lost per 1,000 hours worked) was slightly less than the severity rate for all industries.

The 106 chemical establishments which have reported during each of the past three years show a reduction of 20 per cent in lost-time injuries and of 8 per cent in severity rates.

The general chairman of the Chemical Section program sessions is John S. Shaw, Hercules Powder Co.

Washington Selected for Spring Meeting of A.C.S.

THE symposium on "New Research Tools" which was held under the auspices of the Division of Industrial and Engineering Chemistry, featured the 82d meeting of the American Chemical Society held in Buffalo, N. Y., the week beginning Aug. 30. Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, presided over the symposium, which included papers by W. K. Lewis, E. G. Cottrell, Per K. Frolich, and others well known in the field of research.

On Wednesday evening President Moses Gomberg addressed the members of the society on "Valence, Variation, and Atomic Structure." His address was followed by the presentation of the Jacob F. Schoellkopf Medal to Frank J. Tone, of the Carborundum Co., and the society's award in pure chemistry to Linus Pauling, of the California Institute of Technology.

The council decided in favor of holding the meeting of the society in the spring of 1933 at Washington, D. C., and the fall meeting of the same year at Chicago, Ill.

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France Plans Chemical Equipment Exposition

FOLLOWING the recent exhibition of chemical apparatus in London, which was in part stimulated by the success of the Achema exhibitions organized by the Dechema, the German society for chemical apparatus, a project is now being considered for a similar enterprise in Paris in 1932. The Achema has now received from France, from the Société de Chimie Industrielle, the proposal that these exhibitions be held alternatively in each of the three countries concerned. This arrangement would have the advantage not only of avoiding the simultaneous occurrence in different countries of such exhibitions but also of affording opportunities for mutual study and comparison of methods of production in the different countries. The project was discussed in London and Paris by the founder of the German Achema, Director Dr. Dr. Ing. h.c. Max Buchner.

The prospects are that an international exhibition will be held in Paris in 1932, followed by the German exhibition of chemical apparatus in Cologne in 1933, and a similar English exhibition in London in 1934.

NEWS FROM WASHINGTON

By Paul Wooton

Washington Correspondent of Chem. & Met.

OPPOSITION of the Manufacturing Chemists' Association to an increase in freight rates is predicated on a demonstration that an increase in railroad revenue is dependent upon an increase in tonnage. At the hearing on the railroads' proposal before the Interstate Commerce Commission, Warren N. Watson, secretary of the association, and H. M. Mabey, traffic manager of the Mathieson Alkali Works, submitted on behalf of the industry an analysis of the effect of transportation conditions upon its business.

A canvass of the leading chemical manufacturers, said Mr. Mabey, points to an increased movement beginning this autumn. The effect of a horizontal increase in freight rates, he declared, would not only hinder improvement in the chemical industry but in all industries, as the movement of chemicals is reflected in the movement of manufactured products generally. Mr. Mabey testified that chemical prices have been driven below pre-war levels and that it would be impossible to pass on to the consumer any increase in freight rates. He explained that in the chemical industry increased freight charges are not incidental, as they may be on merchandise moving directly to the consumer, because a tremendous part of its production consists of raw materials moved on annual contracts. Any increase in freight rates consequently places a direct burden upon the manufacturer which cannot be passed along during the life of such contracts.

Mr. Mabey informed the Commission that a horizontal increase in freight rates would have the effect of limiting markets, of encouraging short-haul transportation as against long-haul transportation, and of driving tonnage to ships, trucks, and pipe lines. Relocation of plants will also follow, and this can be done, according to Mr. Mabey, at less expense than in the past. A nickel saved in costs of manufacture and delivery now means far more than when competition is less severe, and industry cannot be liberal, declared Mr. Mabey, when competition has been narrowed down to a battle of costs.

MANUFACTURERS of esters have accepted from the Federal Trade Commission their revised code of trade practices. Group I rules condemn price discrimination, secret rebating and commercial bribery, false branding, and shipment of goods on consignment as unfair methods of competition when the effect may be to lessen competition or tend toward monopoly. The Commission retained Group II rules permitting individual members to publish and circulate independently their own price lists to the purchasing trade and approving the practice of making the terms of sale a part of all published prices.

OSTENSIBLY aimed at Chile, increased duties were applied by Italy on various nitrogen derviatives and fertilizer materials, effective Aug. 21. At the same time a decree was issued permitting free importation of 60,000 tons of crude sodium nitrate, inclusive of quantities imported to date this year. Otherwise, crude sodium nitrate, including synthetic calcium nitrate, duty free in the past, will be dutiable at 55 paper lire per 100 kilos under the general tariff. Previously dutiable at 3.65 paper lire, ammonium sulphate also is subject to the new impost.

A sidelight on the dark outlook of the German nitrogen industry is afforded by the recent decision of the German railways to suspend the project for increasing from two to four the number of tracks from Halle to Weissenfels. This line serves the Merseberg district, in which the gigantic Leuna plant of the I. G. is situated. Thiis plant, which has a capacity of 625,000 tons and accounts for 54 per cent of Germany's total nitrogen production, has been operating at far below capacity for months.

Substantial cuts in German export prices on nitrogenous fertilizers followed expiration of the 14-day truce which was agreed to when the cartel negotiations collapsed. It is reported that since July 28 German ammonium sulphate has been sold in Denmark at 10.20 kroner per 100 kilos, a decrease of 37.4 per cent. Price cuts on other nitrates are not as large. Calcium nitrate, for instance, is down only 9.1 per cent. Announcement of substantial declines, anticipated in the German market, has been delayed.

Resort of the Gum Turpentine and Rosin Marketing Association to the U. S. Timber Conservation Board in the faint hope that this agency would be able to suggest to the "co-op" some way out of its difficulties proved to be futile. The association's representatives were informed that the Board is interested in naval stores to the extent that tapping affects the future supply of saw timber in the South. As the association's representatives did not come to the Board with reference to improving present practice in this direction, they were informed that the Board could do nothing for them. For advice on finding a remedy for the demoralization of the market for turpentine and rosin they were referred to the Federal Farm Board, the Bureau of Agricultural Economics and the Bureau of Foreign and Domestic Commerce.

The latter agency is now undertaking a survey of the production and probable trend of consumption of naval stores.

The Department of Justice has vetoed the request of the Department of Agriculture for an appeal to the U. S. Supreme Court from the decision of the Court of Appeals of the District of Columbia holding that multiple seizures under the Food and Drugs Act are not justified except when the public health is endangered. In a sense the case has become moot, as the National Remedy Co., of Boston, did not contest subsequent seizures of its product. The Department of Agriculture maintains that it resorts to multiple seizures only when public health is jeopardized, but its legal officers desired an appeal, anticipating that as a result of the District courts' decision multiple seizure, cases in the future may be tried in injunction rather than in libel proceedings.

Dispute concerning the application of the provision of the 1929 tariff with reference to marking imported articles with the country of origin has resulted in a ruling sought by E. I. duPont de Nemours & Co. requiring that gelatin bottle caps be individually marked except those so small as to make marking impracticable, in which case it will be sufficient to mark the immediate container.

EVIDENCE in the Interstate Commerce Commission's proceeding on the salt rate structure, as briefed for final argument, discloses a difference of opinion among salt and chemical companies due to increasing use of salt for industrial purposes. The Morton Salt Co. advocates the retention of one rate and one carload minimum on all salt throughout the United States. The Brown company requests adoption of a lower minimum and lower rates on rock salt in carloads, as proposed by itself, the International Salt Co., the Retsof Mining Co., and others. This group contends that there is no sound reason why the manufacturers of chlorine and caustic soda, commodities that are noncompetitive with evaporated or edible salt, should be required to pay evaporated salt rates on crude rock salt.

The present issue concerning industrial salt is new and voluminous evidence in behalf of the Niagara Falls chemical industry is submitted for the first time. This group of companies, which embraces the Hooker Electro-Chemical Co., Isco Chemical Co., Mathieson Alkali Works, Inc., Niagara Smelting Corp., Oldbury Electrro-Chemical Co., and Niagara Alkali Co., advocate a towfold rate and a twofold minimum. They point out that when salt rates were last revised in 1923, it was essentially a producer-shipper case. In the present case the Commission has before it not only the producer interests but a chemical industry which has no direct interest in trademarks or competition between producers of manufactured salt but which must have crude rock salt under reasonable freight rates in order to continue the movement of this low-grade raw material.

Manufacturing Chemists Formulate Program

THE winter program of the Manufacturing Chemists' Association will be outlined at a meeting of the executive committee on Sept. 16 in New York. Several technical committee meetings are scheduled for the remainder of the week in Atlantic City. The bill proposed by Senator Bingham, of Connecticut, for regulating the sale of all poisonous volatile substances under an amendment to the Food and Drugs Act will be given further consideration by a special committee appointed for that purpose several weeks ago. The committee on steel barrels and drums will meet Sept. 15 to review tests of new barrels and a subcommittee of the drum committee will meet on the following day to consider specifications proposed by the Federal Specifications Board. These do not conform with requirements of the Interstate Commerce Commission and consequently drums made in accordance with them could not be used in interstate commerce. The Carboy Committee will meet on Sept. 17 to review developments in selecting a standard carboy to replace the General, Merrimac, and Grasselli types which are now in use. The Traffic Committee and the Tank Car Committee will meet Sept. 18 and Sept. 19, respectively.

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Seven Bids Submitted For Muscle Shoals

AS PROPOSALS received concerning the leasing of Muscle Shoals are regarded as tentative, the commission appointed jointly by President Hoover and the governors of Tennessee and Alabama will make no immediate announcement concerning details of the offers. The commission met on Sept. 1 to receive proposals made by any of the organizations which had been invited to submit bids. Only seven proposals were received on the day specified. Practically every one of these proposals is of a tentative nature.

Although it was stated previously by members of the commission that the most acceptable proposal probably would come from the American Farm Bureau Federation, no proposition has yet been submitted by that organization. It is understood, however, that one is being drafted. A feature of the expected proposal is that it probably will involve a scheme to obtain federal aid in financing the lease. Thus money would be withdrawn from the Treasury as a loan to farm organizations, which in turn would pay it to the War Department for the use of the fertilizer facilities at Muscle Shoals. On the seven tentative proposals received, two come from power companies. These are the Tennessee Electric Power Co. and the Alabama Power Co. These companies are interested only in purchasing such additional power as may be available in connection with the production of fertilizer, it is stated.

Others who submitted tentative proposals were: F. E. Castleberg, of Shreveport; Lloyd H. Smith, of Battle Creek; the Davison Chemical Co., of Baltimore; the Chemical Development Co., of New York City, and the Bailey-Furnace Co., of Canton.

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Canadian Company Will Build Gas Plant

THE B. C. Electric Power & Gas Co. Ltd., Vancouver, B. C., has placed a contract with the Gas Chambers & Coke Ovens, Ltd., of London, England, for the installation of a C.O.L. intermittent vertical chamber oven plant of a daily manufacturing capacity of 3,000,000 cu.ft., to be completed by November, 1932, and to cost approximately $850,000.

Work will start within a month or two and continue throughout the winter. Continued increase in the demand for gas is the reason for the new plant, company officials state. In spite of the mild winter, there was an actual increase in use of gas during the past year, and in normal weather conditions the increase would have amounted to at least 5 per cent.

It is expected that new industrial heating installations will add 8,000,000 cu.ft. a year to the demand in Vancouver, and North Vancouver will require 6,000,000 cu. ft. more when mains are laid across the Second Narrows.

The new plant will consist of 24 vertical chambers, each taking 4½ tons of coal, intermittently charged and discharged; waste heat boilers, coal bunkers, equipment for handling, quenching, screening, and conveying coke, etc. A feature of the new plant will be its ability to produce metallurgical coke for which there is now a demand of only a few thousand tons a year. It will be the first plant in Canada to produce coke of this kind and will be capable of meeting any demand that may arise.

CALENDAR

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, fall meeting, Atlantic City, N. J., Dec. 9-11.

AMERICAN GAS ASSOCIATION, annual meeting, Atlantic City, Oct. 12-16.

MATERIALS HANDLING EXPOSITION, first meeting, New York City, Nov. 30-Dec. 5.

NATIONAL SAFETY COUNCIL, annual meeting, Chicago, Oct. 12-16.

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY, fall meeting, Kalamazoo, Mich., Sept. 24-26.

THIRD INTERNATIONAL CONFERENCE ON BITUMINOUS COAL, Pittsburgh, Nov. 16-21.

Distribution of Chemical Sales in 1929

OVER one-half the sales by manufacturing plants engaged primarily in making chemical (not including chemicals produced in allied industries) are made to users, such as manufacturers of textiles, glass, soap, rubber, paint, varnish, pulp and paper; laundries, municipalities, etc. Data collected for the Census of Distribution show that of the total sales by the manufacturing plants in 1929, amounting to $715,176,000, 61.7 per cent, or $441,272,000, was sold in this way.

Manufacturing plants sold 15.4 per cent, or $110,131,000 worth of goods, to their own wholesale branches for resale to dealers and users. The remaining sales were made as follows: to wholesalers, 21.2 per cent, or $151,842,000; and to retailers, 1.7 per cent, or $11,931,000.

Of the above sales to dealers and users, $44,765,000 was made through manufacturers' agents, selling agents, brokers or commission houses. One hundred twelve plants sold through such agents, 27 of them selling their entire output in this way.

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Standard Oil Interested In Chemical Company

THE California Spray-Chemical Corp. will take over the business of the present California Spray Chemical Co. The Standard Oil Co. of California is participating in the capitalization of the reorganized company. The board of directors of the new California Spray-Chemical Corp. includes K. R. Kingsbury, R. K. Davies, G. E. Kennedy, B. W. Letcher, and P. P. Matt, representing the Standard Oil Co. of California, and E. E. Luther, R. K. Vickery, Paul A. Sinsheimer, and W. H. Volck, representing the predecessor company.

The interest of the Standard Oil Co. of California in this venture lies in the fact that the business centers around the development of a market for sprays which consist principally of mineral oils. The patents acquired by the new corporation give it a preferred position in this field.

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New Iodine Factory In Norway

A NEW Norwegian company for the manufacture of iodine from kelp (sea weed) ash has recently been organized, according to a report from Consul George Orr, Stavanger, Norway. This enterprise is sponsored by an Oslo paint firm. The factory, which it is asserted will require about 500 metric tons of kelp ash annually, is now being constructed near Kopervik, and will be completed in September. There are two other iodine producing concerns in Norway, the Skaalevik Kemiske Fabrikker A/S, at Bergen, and Lofotens Kemiske Fabrikker, at Stamsund.

MARKET CONDITIONS -AND PRICE TRENDS

Quiet Demand for Chemicals In Last Month

Seasonal Influences Expected to Stimulate Buying Interest in Present Month

WHILE shipping instructions against running contracts have been disappointing in the last month, the passing of the summer season is expected to bring an improvement in the call for raw materials. Increased operations in many consuming industries already have been reflected in the market, and seasonal influences may be relied upon to offer a stimulus to trading. Producers of chemicals are reported to be carrying surplus stocks, but productive activities in the last month were adjusted and the price structure of the market has not been disturbed by any weight of offerings.

The nitrogen situation continues to attract attention. Despite reports that a working agreement had been effected by leading European producers, Imperial Chemical Industries, Ltd., has issued the following statement:

"During the last few days, reports have been current regarding a resumption of negotiations for a world nitrogen agreement. These tend to convey an erroneous impression as to the position. The facts are as follows: First, an arrangement has been arrived at between the German and Belgian governments by which modifications are made in certain commercial treaties between those countries so that each government is now free to prohibit the importation of all nitrogenous fertilizers. It is understood that both governments have, in fact, prohibited the importation of all forms of nitrogen except under license.

"Secondly, some of the leading representatives of the Chilean nitrate industry have lately been in session in Brussels, and have had informal conversations with representatives of the Belgian synthetic nitrogen industry in regard to home prices in Belgium for the coming season.

"There has been no resumption of negotiations for a general agreement, and, in view of the causes of the rupture at Lucerne and the present situation, it is considered improbable that such negotiations will be resumed in the near future."

IN CHILE the nitrate situation has become more involved as a result of a motion passed by the Chamber of Deputies authorizing revision of the law which created the Compania Salitrera de Chile. The motion charges that the formation of Cosach was unconstitutional and detrimental to the national interests. In the meantime no new schedule of prices has been issued covering delivery of nitrate of soda to this country.

Reference to import statistics reveals that arrivals of chrome ore from foreign markets have increased considerably over those for the corresponding period of last year. As steel operations have been at low levels, it is apparent that the chemical industry has taken more than its customary percentage of chrome ore. This is borne out by reports that bichromate plants are working at capacity. This in turn is explained by the fact that consumers of bichromates have been fairly active and because a large part of chromic acid requirements is now taken care of by domestic production.

Price concessions have been reported in the case of some chemicals and it cannot be said that a firm tone existed in the market. Yet the large majority of selections underwent no change in quotations and sellers as a rule hold that further price reductions would have no effect in the way of extending trading. In fact, a movement has been sponsored by the chemical industry to prevent further commodity price cutting. Tartaric acid offered an exception to the rule, as considerable competition developed between foreign and domestic producers and sales schedules were revised sharply downward.

Among recent developments of market importance was the announcement that the Monsanto Chemical Works was to begin production of pyrocatechol and phthalyl chloride, two chemicals not hitherto produced in ths country. The Kalbfleisch Corp. reports that it is ready to market gum rosin size in dry form. Newport Chemical Works is offering technical resorcin in the form of flakes which will not solidify in the containers. The Dow Chemical Co. announces a reduction in the price of magnesium metal to 30c. per pound in carlots. That production of potash is gaining in New Mexico is shown by a report that 27 carloads was recently shipped in one day from Carlsbad by the United States Potash Co.

Chem. & Met. Weighted Index of Chemical Prices

Base = 100 for 1927

This month	**86.26**
Last month	85.77
September, 1930	94.38
September, 1929	100.19

In general, prices for chemicals were held at unchanged levels, but sulphate of ammonia and sprits of turpentine were quoted at higher average levels. Denatured alcohol also was higher. Tartaric acid was featured by keen competition, with prices declining.

Materials Consumed in the Fertilizer Industry, 1929 and 1919

	1929	1919
	Short Tons	Short Tons
Cottonseed meal	84,762	230,526
Tankage (animal)	208,809	
Dried blood	12,651	*689,753
Ammonium sulphate-nitrate	36,317	
Calcium nitrate	10,647	
Fish scrap, meal and tankage	149,887	273,252
Sulphate of ammonia	460,505	135,882
Calcium cyanamid (lime nitrogen)	77,389	16,926
Nitrate of soda	240,403	152,415
Bone ground,steamed,etc.	45,676	169,771
Superphosphates:†		
20 per cent or less	1,320,694	1,200,182
Over 40 per cent	47,337	
Whale guano	11,841	33,053
Guano, other	28,966	
Kainite	81,119	31,145
Muriate of potash	228,319	32,900
Sulphate of potash	77,043	79,482
Manure salts	389,884	17,560
Other potash	90,497	154,135
Cost of above materials	$79,827,387	$119,050,550
Phosphate rock	2,291,037	2,247,325
Sulphur	339,088	221,558
Pyrites	201,384	398,602
Sulphuric acid, 50 deg. Baumé:		
Made and consumed	1,373,033	1,568,577
Purchased	922,150	636,632
Superphosphates (20 per cent or less, made and consumed in same establishments	1,601,685	3,316,486
Other materials	869,848	‡

*Includes data for tankage other than animal and for ammoniates not specified.

†Not including superphosphates made and consumed in same establishments.

‡No data.

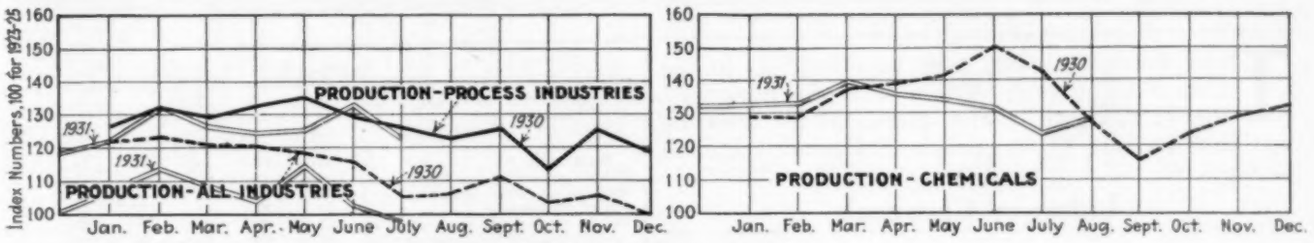
Chem. & Met. Weighted Index of Prices for Oil and Fats

Base = 100 for 1927

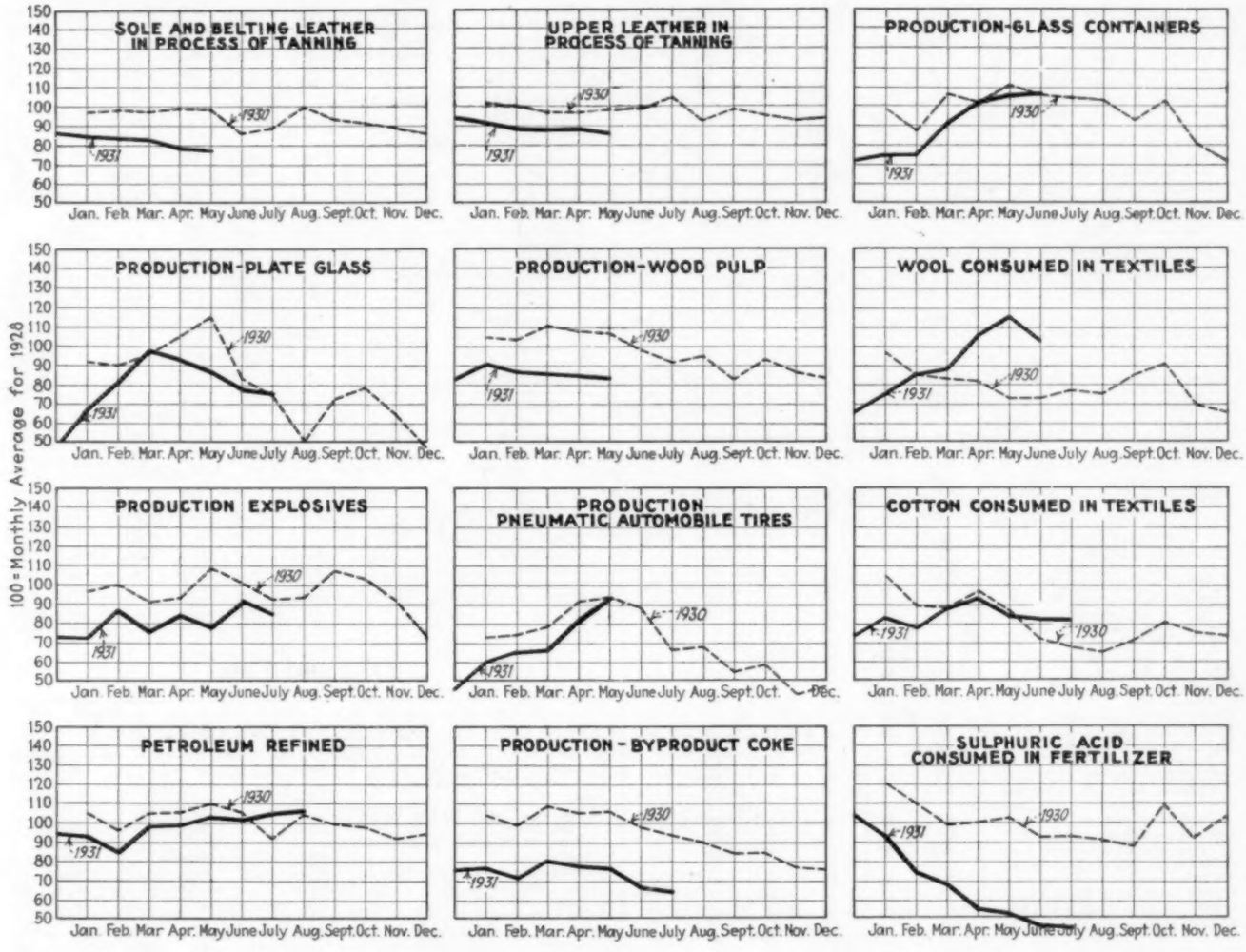
This month	**51.28**
Last month	61.53
September, 1930	77.86
September, 1929	99.81

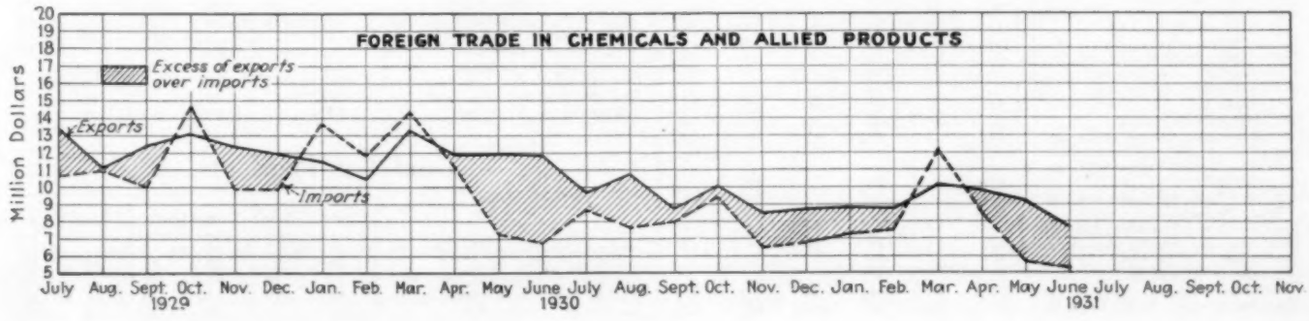
Sharp reductions in values for crude cottonseed oil and linseed oil had much to do with the drop in the index number for the month. With the exception of China wood oil, other vegetable oils added to the downward trend. Tallow likewise was lower.

ACTIVITY IN PRODUCING AND CONSUMING INDUSTRIES



Based on electrical power consumption, data supplied by Electrical World




FOREIGN TRADE IN CHEMICALS AND ALLIED PRODUCTS
Million Dollars
Excess of exports over imports
Exports
Imports
July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov.
1929
1930
1931

CURRENT PRICES *in the* NEW YORK MARKET

THE following prices refer to round lots in the New York market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to Sept. 14.

Industrial Chemicals

	Current Price	Last Month	Last Year
Acetone, drums, lb.	$0.10 -$0.11	$0.10 -$0.11	$0.11 -$0.12
Acid, acetic, 28%, bbl., cwt.	2.60 - 2.85	2.60 - 2.85	3.11 - 3.26
Glacial 99%, tanks	8.98 -	8.98 -	10.76 -
drs.	9.23 - 9.48	9.23 - 9.48	11.01 -
U. S. P. reagent, c'bys.	9.73 - 9.98	9.73 - 9.98	11.51 -
Boric, bbl, lb.	.06½- .07	.06½- .07	.06½- .07
Citric, kegs, lb.	.35 - .36	.35 - .36	.46 - .47
Formic, bbl, lb.	.10 - .11	.10 - .11	.10 - .11
Gallic, tech., bbl., lb.	.50 - .55	.50 - .55	.50 - .55
Hydrofluoric 30% carb, lb.	.06 - .07	.06 - .07	.06 - .07
Lactic, 44%, tech., light, bbl, lb.	.11½- .12	.11½- .12	.11½- .12
22%, tech., light, bbl., lb.	.05½- .06	.05½- .06	.05½- .06
Muriatic, 18°, tanks, cwt.	1.00 - 1.10	1.00 - 1.10	1.00 - 1.10
Nitric, 36°, carboys, lb.	.05 - .05½	.05 - .05½	.05 - .05½
Oleum, tanks, wks., ton	18.50 -20.00	18.50 -	18.50- 20.00
Oxalic, crystals, bbl., lb.	.11 - .11½	.11 - .11½	.11 - .12
Phosphoric, tech., c'bys., lb.	.08½- .09	.08½- .09	.08½- .09
Sulphuric, 60°, tanks, ton	11.00 -11.50	11.00 -11.50	11.00 -11.50
Tannic, tech., bbl., lb.	.23 - .35	.23 - .35	.35 - .40
Tartaric, powd., bbl., lb.	.27½- .28½	.30½- .33	.34 - .36
Tungstic, bbl., lb.	1.40 - 1.50	1.40 - 1.50	1.40 - 1.50
Alcohol, ethyl, 190 p'f., bbl., gal.	2.33 -	2.33 -	2.63 - 2.71
Alcohol, Butyl, tanks, lb.	.15½-	.15½-	.16½- .17
Alcohol, Amyl	-	-	-
From Pentane, tanks, lb.	.203-	.203-	- .236
Denatured, 188 proof			
No. 1 special dr., gal.	.28 -	.28 -	.40 -
No. 5, 188 proof, dr., gal.	.28 -	.28 -	.40 -
Alum, ammonia, lump, bbl., lb.	.03½- .04	.03½- .04	.03½- .04
Chrome, bbl., lb.	.04½- .05	.04½- .05	.05½- .06
Potash, lump, bbl., lb.	.03½- .04	.03½- .04	.03 - .03½
Aluminum sulphate, com., bags, cwt.	1.25 - 1.40	1.25 - 1.40	1.40 - 1.45
Iron free, bg., cwt.	1.90 - 2.00	1.90 - 2.00	1.90 - 2.00
Aqua ammonia, 26°, drums lb	.02½- .03	.02½- .03	.03 - .04
tanks, lb.	.02½- .02½	.02½- .02½	.02½- .02½
Ammonia, anhydrous, cyl., lb	.15½- .15½	.15½- .15½	.15½-
tanks, lb.	.05½-	.05½-	.05½-
Ammonium carbonate, powd. tech., casks, lb.	.10½- .11	.10½- .11	.10½- .11
Sulphate, wks., cwt.	1.30 -	1.20 -	1.70 -
Amylacetate tech., tanks, lb., gal	.172-	.172-	.222-
Antimony Oxide, bbl., lb.	.08 - .09	.08 - .09	.09 - .10
Arsenic, white, powd., bbl., lb.	.04 - .04½	.04 - .04½	.04 - .04½
Red, powd., kegs, lb.	.09 - .10	.09 - .10	.09 - .10
Barium carbonate, bbl., ton	56.50 -58.00	56.50 -58.00	58.00 -60.00
Chloride, bbl., ton	63.00 -65.00	63.00 -65.00	64.00 -70.00
Nitrate, cask, lb.	.07 - .07½	.07 - .07½	.07 - .07½
Blanc fixe, dry, bbl., lb.	.03½- .04	.03½- .04	.03½- .04
Bleaching powder, f.o.b., wks., drums, cwt.	2.00 - 2.10	2.00 - 2.10	2.00 - 2.10
Borax, grain, bags, ton	50.00 - 57.00	50.00 - 57.00	50.00 -57.00
Bromine, cs., lb.	.36 - .38	.36 - .38	.45 - .47
Calcium acetate, bags	2.00 -	2.00 -	3.00 -
Arsenate, dr., lb.	.06 - .07	.06 - .07	.07 - .08
Carbide drums, lb.	.05 - .06	.05 - .06	.05 - .06
Chloride, fused, dr., wks., ton.	20.00 -	20.00 -	20.00 -
flake, dr., wks., ton.	22.75 -	22.75 -	22.75 -
Phosphate, bbl., lb.	.08 - .08½	.08 - .08½	.08 - .08½
Carbon bisulphide, drums, lb.	.05 - .06	.05 - .06	.05 - .06
Tetrachloride drums, lb.	.06½- .07	.06½- .07	.06½- .07
Chlorine, liquid, tanks, wks., lb.	.01½-	.01½-	.024-
Cylinders	.04 - .06	.04 - .06	.04½- .06
Cobalt oxide, cans, lb.	1.35 - 1.45	1.35 - 1.45	2.10 - 2.25
Copperas, bgs., f.o.b. wks., ton	13.00 -14.00	13.00 -14.00	13.00 -14.00
Copper carbonate, bbl., lb.	.08½- .18	.08½- .17	.09 - .18
Cyanide, tech., bbl., lb.	.41 - .46	.41 - .46	.45 - .46
Sulphate, bbl., cwt.	3.60 - 3.75	3.60 - 3.75	4.25 - 4.50
Cream of tartar, bbl., lb.	.22½- .22½	.22½- .23	.26 - .27
Diethylene glycol, dr., lb.	.14 - .16	.14 - .16	.11 - .13
Epsom salt, dom., tech., bbl., cwt.	1.70 - 2.00	1.70 - 2.00	1.75 - 2.00
Imp., tech., bags, cwt.	1.15 - 1.25	1.15 - 1.25	1.15 - 1.25
Ethyl acetate, drums, lb.	.06 -	.06 -	.096-
Formaldehyde, 40%, bbl., lb.	.06 - .07	.06 - .07	.07½- .08
Furfural, dr., contract, lb.	.10 - .12	.10 - .12	.10 - .12
Fusel oil, crude, drums, gal.	1.10 - 1.20	1.10 - 1.20	1.30 - 1.40
Refined, dr., gal.	1.80 - 1.90	1.80 - 1.90	1.90 - 2.00
Glaubers salt, bags, cwt	1.00 - 1.10	1.00 - 1.10	1.00 - 1.10
Glycerine, c.p., drums, extra., lb.	.11½- .12	.11½- .12	.13 - .14
Lead:			
White, basic carbonate, dry casks, lb.	.07½-	.07½-	.07½-
White, basic sulphate, sck., lb.	.07 -	.07 -	.07½-
Red, dry, sck., lb.	.07½-	.07½-	.09 -
Lead acetate, white crys., bbl., lb	.11 - .12	.11 - .12	.12 - .13
Lead arsenate, powd., bbl., lb.	.10 - .14	.10 - .14	.13 - .14
Lime, chem., bulk, ton	8.50 -	8.50 -	8.50 -
Litharge, pwd., csk, lb.	.06½-	.06½-	.08 -
Lithopone, bags, lb.	.04½- .05	.04½- .05	.05½- .06½
Magnesium carb., tech., bags, lb.	.06 - .06½	.06 - .06½	.06 - .06½
Methanol, 95%, tanks, gal.	.33 -	.33 -	.38 -
97%, tanks, gal.	.34 -	.34 -	.39 -
Synthetic, tanks, gal.	.35½-	.37½-	.40½- .45
Nickel salt, double, bbl., lb.	.10½- .11	.10½- .11	.13 - .13½
Single, bbl., lb.	.10½- .11	.10½- .11	.13 - .13½
Orange mineral, csk., lb.	.09½-	.09½-	.11 -
Phosphorus, red, cases, lb.	.42 - .44	.42 - .44	.42 - .44
Yellow, cases, lb.	.31 - .32	.31 - .32	.31 - .32
Potassium bichromate, casks, lb	.09 - .09½	.09 - .09½	.09 - .09½
Carbonate, 80-85%, calc., csk., lb	.05 - .05½	.05½- .06	.05½- .06
Chlorate, powd., lb.	.08 - .08½	.08 - .08½	.08½- .09
Cyanide, cs., lb.	.55 - .57	.55 - .57	.52 - .55
First sorts, csk., lb.	.08½- .09	.08½- .09	.05½- .09
Hydroxide (c'stic potash) dr., lb	.06½- .06½	.06½- .06½	.06½- .06½
Muriate, 80% bgs., ton	37.15 -	37.15 -	37.15 -
Nitrate, bbl., lb.	.05½- .06	.05½- .06	.06 - .07½
Permanganate, drums, lb.	.16 - .16½	.16 - .16½	.16 - .16½
Prussiate, yellow, casks, lb.	.18½- .19½	.18½- .19	.18½- .19
Salammoniac, white, casks, lb	.04½- .05	.04½- .05	.047- .05
Salsoda, bbl., cwt.	.90 - .95	.90 - .95	.90 - .95
Salt cake, bulk, ton	16.00 -18.00	16.00 -18.00	20.00 -22.00
Soda ash, light, 58%, bags, contract, cwt.	1.15 -	1.15 -	1.32 -
Dense, bags, cwt.	1.17½-	1.17½-	1.35 -
Soda, caustic, 76%, solid, drums, contract, cwt.	2.50 - 2.75	2.50 - 2.75	2.90 - 3.00
Acetate, works, bbl., lb.	.05½- .06	.05½- .05½	.04 - .05
Bicarbonate, bbl., cwt.	1.85 - 2.00	1.85 - 2.00	2.00 - 2.25
Bichromate, casks, lb.	.07 - .07½	.07 - .07½	.07 - .07½
Bisulphate, bulk, ton	14.00 - 16.00	14.00 -16.00	14.00 -16.00
Bisulphite, bbl., lb.	.03½- .04	.03½- .04	.03½- .04
Chlorate, kegs, lb.	.05½- .07½	.05½- .07½	.07½- .08
Chloride, tech., ton	12.00 -14.75	12.00- 14.75	12.00 -14.00
Cyanide, cases, dom., lb.	.16½- .17	.16½- .17	.18 - .20
Fluoride, bbl., lb.	.07½- .08	.07½- .08	.08 - .09
Hyposulphite, bbl., lb.	2.40 - 2.50	2.40 - 2.50	2.40 - 2.50
Nitrate, bags, cwt.	2.05 -	2.05 -	1.99 -
Nitrite, casks, lb.	.07½- .08	.07½- .08	.07½- .08
Phosphate, dibasic, bbl., lb.	.0265- .03	.0265- .03	.03¼- .03½
Prussiate, yel. drums, lb.	.11½- .12	.11½- .12	.11½- .12
Silicate (30°, drums), cwt.	.60 - .70	.60 - .70	.60 - .70
Sulphide, fused, 60-62%, dr., lb.	.02½- .03½	.02½- .03	.03½- .04
Sulphite, cyrs., bbl., lb.	.03 - .03½	.03 - .03½	.02 - .03
Sulphur, crude at mine, bulk, ton	18.00 -	18.00 -	18.00 -
Chloride, dr., lb.	.05 - .06	.05 - .06	.05 - .06
Dioxide, cyl., lb.	.06½- .07	.06½- .07	.07 - .08
Flour, bag, cwt.	1.55 - 3.00	1.55 - 3.00	1.55 - 3.00
Tin bichloride, bbl., lb.	nom. -	nom. -	nom. -
Oxide, bbl., lb.	.27½-	.27 -	.36 -
Crystals, bbl., lb.	.25½-	.25 -	.27½-
Zinc chloride, gran., bbl., lb.	.06½- .06½	.06½- .06½	.06½- .06½
Carbonate, bbl., lb.	.10½- .11	.10½- .11	.10 - .11
Cyanide, dr., lb.	.41 - .42	.41 - .42	.40 - .41
Dust, bbl., lb.	.05½- .06	.05½- .06	.07½- .08
Zinc oxide, lead free, bag, lb.	.06½-	.06½-	.06½-
5% lead sulphate, bags, lb.	.06½-	.06½-	.06½-
Sulphate, bbl., cwt.	3.00 - 3.25	3.00 - 3.25	3.00 - 3.25

Oils and Fats

	Current Price	Last Month	Last Year
Castor oil, No. 3, bbl., lb.	$0.10½-$0.11	$0.10½-$0.11	$0.11½-$0.12½
Chinawood oil, bbl., lb.	.06½-	.07 -	.09½-
Coconut oil, Ceylon, tanks, N.Y., lb.	.03½-	.04½-	.06½
Corn oil crude, tanks, (f.o.b. mill), lb.	.05½-	.06½	.07½-
Cottonseed oil, crude (f.o.b. mill), tanks, lb.	.03½-	.05½-	.06½-
Linseed oil, raw, car lots, bbl., lb.	.075-	.085	.106-
Palm, Lagos, casks, lb.	.04½-	nom.	.06½-
Niger, casks, lb.	.04½-	nom.	.06 -
Palm Kernel, bbl., lb.	.05 -	.05 -	.06½-
Peanut oil, crude, tanks (mill), lb.	.05 -	.07 -	.07½-
Rapeseed oil, refined, bbl., gal.	.45 - .47	.45 - .47	.58 - .60
Soya bean, tank (f.o.b. Coast), lb.	nom. -	nom. -	.08½-
Sulphur (olive foots), bbl., lb.	.04½-	.04½-	.07½-
Cod, Newfoundland, bbl., gal.	.35 - .36	.40 - .44	.55 - .57
Menhaden, light pressed, bbl., gal	.34 - .36	.34 - .36	.47 - .49
Crude, tanks (f.o.b. factory), gal.	.17½-	.17½-	.28 -
Whale, crude, tanks, gal.	nom. -	nom -	- .78
Grease, yellow, loose, lb.	.02 -	.02½-	.04½-
Oleo stearine, lb.	.07½-	.07½-	.08½-
Red oil, distilled, d.p. bbl., lb	.07½-	.07½-	.10½-
Tallow, extra, loose, lb.	.02½-	.03½-	.05½-

Coal-Tar Products

	Current Price	Last Month	Last Year
Alpha-naphthol, crude, bbl., lb.	$0.60 -$0.65	$0.60 -$0.65	$0.60 -$0.62
Refined, bbl., lb.	.80 - .85	.80 - .85	.80 - .85
Alpha-naphthylamine, bbl., lb.	.32 - .34	.32 - .34	.32 - .34
Aniline oil, drums, extra, lb.	.14½- .15	.14½- .15	.15 - .16
Aniline salts, bbl., lb.	.24 - .25	.24 - .25	.24 - .52

Coal-Tar Products (Continued)

	Current Price	Last Month	Last Year
Benzaldehyde, U.S.P., dr., lb.	1.10 - 1.25	1.10 - 1.25	1.15 - 1.25
Benzidine base, bbl., lb.	.65 - .67	.65 - .67	.65 - .67
Benzoic acid, U.S.P., kgs, lb.	.48 - .52	.48 - .52	.57 - .60
Benzyl chloride, tech., dr., lb.	.30 - .35	.30 - .35	.30 - .35
Benzol, 90%, tanks, works, gal.	.18 - .19	.18 - .19	.21 - .22
Beta-naphthol, tech., drums, lb.	.22 - .24	.22 - .24	.22 - .24
Cresol, U.S.P., dr., lb.	.12½ - .14	.12½ - .14	.14 - .17
Cresylic acid, 97%, dr., wks., gal.	.54 - .58	.54 - .58	.60 - .70
Diethylaniline, dr., lb.	.55 - .58	.55 - .58	.55 - .58
Dinitrophenol, bbl., lb.	.29 - .30	.29 - .30	.30 - .31
Dinitrotoleun, bbl., lb.	.16 - .17	.16 - .17	.16 - .17
Dip oil, 25% dr., gal.	.26 - .28	.26 - .28	.26 - .28
Diphenylamine, bbl., lb.	.38 - .40	.38 - .40	.39 - .40
H-acid, bbl., lb.	.65 - .70	.65 - .70	.68 - .70
Naphthalene, flake, bbl., lb.	.03½ - .04½	.03½ - .04½	.04½ - .05
Nitrobenzene, dr., lb.	.08½ - .09	.08½ - .09	.08½ - .10
Para-nitraniline, bbl., lb.	.51 - .55	.51 - .55	.51 - .55
Para-nitrotoluine, bbl., lb.	.29 - .30	.29 - .31	.29 - .31
Phenol, U.S.P., drums, lb.	.14½ - .15	.14½ - .15	.14½ - .15
Picric acid, bbl., lb.	.30 - .40	.30 - .40	.30 - .40
Pyridine, dr., lb.	1.50 - 1.75	1.50 - 1.80	1.50 - 1.80
R-salt, bbl., lb.	.40 - .44	.40 - .44	.44 - .45
Resorcinal, tech., kegs, lb.	.70 - .80	.70 - .80	1.15 - 1.25
Salicylic acid, tech., bbl., lb.	.33 - .35	.33 - .35	.33 - .35
Solvent naphtha, w.w., tanks, gal.	.25 - .30	.25 -	.28 - .30
Tolidine, bbl., lb.	.86 - .88	.86 - .88	.91 - .93
Toluene, tanks, works, gal.	.27 -	.27 -	.35 - .....
Xylene, com., tanks, gal.	.24 - .25	.24 - .25	.25 - .28

Miscellaneous

	Current Price	Last Month	Last Year
Barytes, grd., white, bbl., ton	$23.00-$25.00	$23.00-$25.00	$23.00-$25.00
Casein, tech., bbl., lb.	.06 - .11	.06 - .11	.13½ - .16
China clay, dom., f.o.b. mine, ton	8.00 -20.00	8.00 -20.00	8.00 -20.00
Dry colors:			
Carbon gas, black (wks.), lb.	.03 - .20	.03 - .20	.05 - .22
Prussian blue, bbl., lb.	.35 - .36	.35 - .36	.35 - .36
Ultramine blue, bbl., lb.	.06 - .32	.06 - .32	.06 - .32
Chrome green, bbl., lb.	.27 - .28	.27 - .28	.27 - .30
Carmine red, tins, lb.	5.00 - 5.40	5.00 - 5.40	6.00 - 6.50
Para toner, lb.	.75 - .80	.75 - .80	.77 - .80
Vermilion, English, bbl., lb.	1.55 - 1.60	1.55 - 1.60	1.90 - 2.00
Chrome yellow, C. P., bbl., lb.	.16½ - .17	.16½ - .17	.17 - .17½
Feldspar, No. 1 (f.o.b. N.C.), ton	6.50 - 7.50	6.50 - 7.50	6.50 - 7.50
Graphite, Ceylon, lump, bbl., lb.	.07 - .08½	.07 - .08½	.04 - .05
Cum copal Congo, bags, lb.	.06 - .08	.06 - .08	.07½ - .08
Manila, bags, lb.	.16 - .17	.16 - .17	.16 - .17
Damar, Batavia, cases, lb.	.16 - .16½	.16 - .19	.18 - .19
Kauri No. 1 cases, lb.	.45 - .48	.45 - .48	.48 - .53
Kieselguhr (f.o.b. N. Y.), ton	50.00 -55.00	50.00 -55.00	50.00 -55.00
Magnesite, calc, ton	40.00 -.....	40.00 -.....	40.00 -.....
Pumice stone, lump, bbl., lb.	.05 - .07	.05 - .08	.05 - .07
Imported, casks, lb.	.03 - .40	.03 - .40	.03 - .35
Rosin, H., bbl.	4.25 -.....	4.15 -.....	6.15 -.....
Turpentine, gal.	.38 -.....	.35½ -.....	.43½ -.....
Shellac, orange, fine, bags, lb.	.38 - .40	.38 - .40	.50 - .52
Bleached, bonedry, bags, lb.	.28 - .30	.28 - .30	.36 - .37
T. N. bags, lb.	.16 - .17	.16 - .17	.27 - .28
Soapstone (f.o.b. Vt.), bags, ton	10.00 -12.00	10.00 -12.00	10.00 -12.00
Talc, 200 mesh (f.o.b. Vt.), ton	8.00 - 8.50	8.00 - 8.50	9.50 -.....
300 mesh (f.o.b. Ga.), ton	7.50 -10.00	7.50 -10.00	7.50 -11.00
225 mesh (f.o.b. N. Y.), ton	13.75 -.....	13.75 -.....	13.75 -.....

	Current Price	Last Month	Last Year
Wax, Bayberry, bbl., lb.	$0.19½ - $0.22	$0.19½ - $0.22	$0.22 - $0.24
Beeswax, ref., light, lb.	.26 - .27	.26 - .27	.35 - .36
Candelilla, bags, lb.	.13 - .14	.14 - .15	.18 - .19
Carnauba, No. 1, bags, lb.	.35 - .36	.28 - .29	.28 - .29
Paraffine, crude			
105-110 m.p., lb.	03½ - 03¾	03½ - 03¾	.04¾ - .05

Ferro-Alloys

	Current Price	Last Month	Last Year
Ferrotitanium, 15-18%, ton	$200.00-.....	$200.00-.....	$200.00-.....
Ferromanganese, 78-82%, ton	80.00 85.00	80.00 85.00	94.00 99.00
Ferrochrome, 65-70%	.11-.....	.11-.....	.....
Spiegeleisen, 19-21%, ton	30.00-.....	30.00-.....	34.00 .....
Ferrosilicon, 14-17%, ton	39.00-.....	39.00-.....	39.00-.....
Ferrotungsten, 70-80%, lb.	1.00- 1.10	1.00- 1.10	1.20 .....
Ferrovanadium, 30-40%, lb.	3.15- 3.50	3.15- 3.50	3.15-3.50

Non-Ferrous Metals

	Current Price	Last Month	Last Year
Copper, electrolytic, lb.	$0.07½-.....	$0.07½-.....	$0.10¼ .....
Aluminum, 96-99%, lb.	.233-.....	.233-.....	.233 -.....
Antimony, Chin. and Jap., lb.	.066	.0665-.....	.08 -.....
Nickel, 99%, lb.	.35 -	.35 -	.35 - .....
Monel metal, blocks, lb.	.28	.28	.28 - .....
Tin, 5-ton lots, Straits, lb.	.25¼-.....	.244	.301 .....
Lead, New York, spot, lb.	.044-	.044-	.055 - .....
Zinc, New York, spot, lb.	.0415	.0385-.....	.046 - .....
Silver, commercial, oz.	.28 -	.27¾	.36 - .....
Cadmium, lb.	.55 -	.55	.70 .....
Bismuth, ton lots, lb.	1.50 -	1.50	1.00 - .....
Cobalt, lb.	2.50 -	2.50	2.50 - .....
Magnesium, ingots, 99%, lb.	.48 -	.48	.85 - 1.10
Platinum, ref., oz.	40.00	40.00	43.00 .....
Palladium ref., oz.	19.00- 21.00	19.00 21.00	23.00 24.00
Mercury, flask, 75 lb.	80.00	82.00	117.00 .....
Tungsten powder, lb.	1.65	1.65	1.70 - 1.75

Ores and Semi-finished Products

	Current Price	Last Month	Last Year
Bauxite, crushed, wks., ton	$6.50- $8.25	$6.50- $8.25	$7.50 $8.00
Chrome ore, c.f. post, ton	17.00- 20.00	17.00- 20.00	21.50 25.00
Coke, fdry., f.o.b. ovens, ton	2.75- 2.85	2.75- 3.85	2.75 - 2.85
Fluorspar, gravel, f.o.b. Ill., ton	17.25- 20.00	17.25- 20.00	18.00- 20.00
Manganese ore, 50% Mn., c.i.f. Atlantic Ports, unit	.24 - .25	.24 - .25	.31 - 36
Molybdenite, 85% MoS_2 per lb. MoS_2, N. Y., lb.	.35 - .40	.35 - .40	.48- .50
Monazite, 6% of ThO_2, ton	60.00 -.....	60.00 -.....	60.00-.....
Pyrites, Span. fines, c.i.f., unit	.13 -.....	.13 -.....	.13 -.....
Rutile, 94-96% TiO_2, lb.	.10 - .11	.10 - .11	.10 - .11
Tungsten, scheelite, 60% WO_3 and over, unit	11.25 - 12.00	11.25 - 12.00	15.25 -16.50

CURRENT INDUSTRIAL DEVELOPMENTS

New Construction and Machinery Requirements

Aluminum Plant—Aluminum Specialty Co., 17th and Wallmer Sts., Manitowoc, Wis., awarded contract for a 3 story, 45 x 60 ft. plant and warehouse to Kasper Construction Co., 4 North 8th St., Manitowoc.

Abrasive Products Factory—Norton Co., 1 New Bond St., Worcester, Mass., manufacturers of abrasive products, grinding machinery, etc., will soon award contract for a 3 story, 100 x 144 ft. factory, storage and distribution plant at Pittsburgh, Pa. Estimated cost $75,000.

Asphaltic Paving Material Factory — Ohio Colprovia Co., 1276 West Third St., Cleveland, O., plans the construction of a plant at Sandusky for the manufacture of asphaltic paving material used in resurfacing streets. Estimated cost $125,000. Private plans.

Cement Plant — National Cement Co., Goose Creek, Tex., plans the construction of a cement plant. Estimated cost $50,000.

Chemical Plant—Flint Eaton Co., G. R. Flint, Pres., 148 North Franklin St., Decatur, Ill. (pharmaceutical chemists), is having preliminary plans prepared for a 2 story plant and office building on North Water St. Estimated cost $50,000. Brooks-Bramhall-Dague, National Bank Bldg., Decatur, are architects.

Chemical Plant—Stauffer Chemical Co., Rives-Strong Bldg., Los Angeles, Calif., will soon award contract for a 1 story, 100 x 160 ft. chemical plant on Wilmington Ave. Estimated cost $50,000.

Rolling Mill—Dow Chemical Co., Midland, Mich., is having plans prepared for the construction of a 1 story rolling mill for magnesium alloy sheets. Estimated cost $50,000. Private plans. Equipment including electric motors, heat treating furnaces, straightening mill and fabricating equipment for sheets to 5 ft. in width will be required.

Copper Factory—Corro de Pasco Copper Co., 44 Wall St., New York and Cerro de Pasco, Peru, sinking shaft construction, hoist house and miscellaneous construction. Estimated cost $300,000. Work will be done by day labor and separate contracts. Hoisting equipment, direct current motor, etc., awarded to Westinghouse Electric & Mfg. Co., 150 Broadway, New York. $40,000.

Creosoting Plant—J. J. Seguin Co. Ltd., St. Lambert, Que., plans the construction of a creosoting plant on a 65 acre site along Canadian National Railways main line to include a cylinder 8 ft. in diameter and 107 ft. in length for pressure treatment of railroad ties, bridge timber, structural timbers, construction lumber, poles and pilings. Estimated cost $200,000. Equipment consists of Rueping tanks, mixing and measuring tanks, compressors for creation of vacuum, etc.

Fertilizer Plant — American Fertilizer & Chemical Works, T. F. Hawkins, Pres., San Saba, Tex., plans the construction of a commercial fertilizer manufacturing plant 100 ton daily capacity to include pulverizing manufacturing and mixing building, weighting, shipping and storage building, machinery and equipment, etc. at San Antonio. Estimated cost $75,000. Private plans.

Fertilizer Plant—Evercyclic Corp., Midland, Tex., plans a plant for the manufacture of fertilizer from sulphur gas extracted from gas fields in Crane County, 5 ton daily capacity. Private plans.

Fertilizer Plant—Pacific Bone Coal & Fertilizer Co., Financial Center Bldg., San Francisco, Calif., awarded contract for addition to plant at South San Francisco, to Austin Co., Russ Bldg., San Francisco. Estimated cost $100,000.

Fertilizer Plant—Virginia Carolina Chemical Corp., Richmond Trust Bldg., Richmond, Va., awarded contract for the construction of a 4 story, 160 x 368 ft. fertilizer plant to include 1 story, 20 x 70 ft. bagged fertilizer building, 28 x 80 ft. storage building, 30 x 60 ft. bag house and storeroom building, 16 x 42 ft. tractor, storage and repair shop, etc. at Fairmount City, Ill. to Austin Co., Arcade Bldg., St. Louis, Mo. $68,100.

Coke Pocket, Etc.—New York & Queens Gas Co., 132-21 Roosevelt Ave., Flushing, N. Y., awarded contract for a coke pocket, etc. on Flushing River at Newtown to Nicholson Co., 405 Lexington Ave., New York. Estimated cost $40,000.

Gas Plant—Central Hudson Gas & Electric Co., 50 Market St., Poughkeepsie, N. Y., has been granted permit by Public Service Commission to construct a butane-air gas plant, 156,000 cu.ft. daily capacity, also distribution system at Coxsackie. Estimated total cost $43,121.

Gas Plant — City of Ruston, La. voted $180,000 bonds for the construction of a gas plant. Charles C. Coyne, Mayor.

Gas Plant—Consolidated Gas Co., Irving Pl., New York, N. Y., had plans prepared for a gas exhaust house and conveyor at Hunts Point Ave. and Bronx River. Private plans. Estimated total cost $45,000.

Gas Plant—New York & Richmond Gas Co., 691 Bay St., St. George, S. I., N. Y., abandoned plans for a 1 story illuminating gas plant at Richmond Ave. and Sycamore St., Eltingville. Estimated cost $40,000. Building permit denied.

Gas Plant—Northern Gas Utilities Co. Inc., 15 Congress St., Boston, Mass., plans the construction of a gas plant at Provincetown. Estimated cost $70,000. G. H. Stevens, 141 Milk St., Boston, is architect.

Kiln—Edwin M. Knowles China Co., Newell, W. Va., awarded contract for the construction of an electric tunnel kiln at new plant to Electric Furnace Co., Salem, O. Estimated cost $50,000.

Chemistry Building—A. & M. College, College Station, Tex., will build a chemistry building. Estimated cost $350,000. E. F. Giesecke, College Station, is architect. Work will be done by owners' forces under the supervision of William Orth.

Laboratory (Chemistry and Biological) — California Institute of Technology, Pasadena, Calif., will receive bids about Oct. 1, for the construction of 3 story chemistry and biological laboratory buildings on East Califronia St. Estimated cost $400,000. Mayers, Murray, Phillips & Goodhue, 2 West 47th St., New York, N. Y., are architects.

Laboratory (Chemistry and Physics)—Radcliff College, 10 Garden St., Cambridge, Mass., awarded contract for a 3 story chemistry and physics laboratory to M. C. Tuttle Co., Park Sq. Bldg., Boston. Estimated cost $40,000.

Laboratory (Forest Products) — Dept. of Agriculture, Washington, D. C., awarded contract for a 6 story, 277 x 469 ft. forest products laboratory building at Madison, Wis., to C. B. Fritz & Co., Madison. $727,648.

Laboratory—City of Ottawa, Ont., awarded contract for extension to laboratory building and pumping station in connection with water filtration plant to Henri Dagenais Ltd., St. Patrick St., Ottawa. $155,658.

Laboratory — Dept. of Health, State Office Bldg., Albany, N. Y., will soon award contract for the construction of a laboratory and animal house at Institute for the Study of Malignant Diseases, Springville.

Laboratory—Rockefeller Institute, York Ave. and 66th St., New York, N. Y., is having sketches made for the construction of a laboratory of animal and plant pathology at Princeton, N. J. Estimated cost $150,000. Coolidge, Shepley, Bulfinch & Abbott, Ames Bldg., Boston, Mass., are architects.

Laboratory Equipment—Board of Education, F. G. Hogen, Dir., Cleveland, O., will receive bids until Oct. 5 for laboratory and library equipment for three new high schools.

Soil Science Building—A. Merchant, 1 Elm Row, New Brunswick, N. J., Archt., will receive bids about Dec. 1, for the construction of a 2 story soil science building at State Experimental Farm for Rutgers University, College Ave., New Brunswick. Estimated cost $150,000.

Lead Factory—United Lead Co., Maurer, N. J., plans the construction of a 2 story factory at South Amboy. Estimated cost $40,000. Architect not selected.

Leather Plant—United Shank & Findings Co., c/o United Shoe Machinery Co., 140 Federal St., Boston, Mass., will soon award contract for the construction of a raw leather plant at Whitman. Estimated cost $40,000. C. W. Hull, c/o owner, is architect.

Leather Plant Addition — Ohio Leather Co., Girard, O., awarded contract for addition to plant to Heller Bros., Thurman & Furnace Sts., Youngstown. Estimated cost to exceed $40,000 including equipment.

Linoleum Factory — Congoleum-Nairn Inc., 195 Belgrove Dr., Kearny, N. J., is having preliminary plans prepared for the construction of a factory for the manufacture of linoleum, felt base floor covering, etc. at Bay Point, Calif. Estimated cost $1,500,000. Sanderson & Porter, 1 Montgomery St., San Francisco, are architects.

Match Factory—Western Australia Match Co. Ltd., c/o Federal Match Co., Melbourne, Australia, plans the construction of a factory at West Perth. Estimated cost to exceed $40,000.

Pipe Mill—Spang Chalfant & Co. Inc., Clark Bldg., Pittsburgh, Pa., awarded contract for a 1 story, 125 x 500 ft. experimental electric weld pipe mill at Ambridge to American Bridge Co., Frick Bldg., Pittsburgh. $1,000,000.

Paper Mill — Marathon Paper Mills Co., Menasha, Wis., awarded contract for the construction of a 1 story plant and warehouse for paper mill to Fluor Bros. Construction Co., 48 Otter St., Oshkosh. Estimated cost $40,000.

Pulp and Paper Mill—Department of Forestry & Geological Development, Capitol Bldg., Atlanta, Ga., plans the construction of a mill to experiment with production of paper from pine wood in Georgia, exact location not yet determined. Estimated cost $70,000. C. H. Herty, 101 Park Ave., New York, is engineer. Maturity soon.

Gasoline Plant — Pure Distributing Corp., Corpus Christi, Tex., subsidiary of Pure Oil Co. of Chicago, 35 East Wacker Dr., Chicago, Ill., will build a gasoline manufacturing plant, 120,000 gal. capacity, at Hansen and F Sts., Harlingen. Work will be done by owners' forces. Estimated cost $40,000. Private plans.

Oil Asphalt and Manufacturing Plants — United Socialist Soviet Russia, c/o Amtorg Trading Corp., 261 5th Ave., New York, N. Y., plans lubricating oil asphalt and manufacturing plants at Moscow, Samara and Stalingrad, also pipe line, 1,750 mi. from Armavir in North Caucasus to Lisky with later extension to Moscow. Maturity in 1932 and later.

Oil Plant—Freedom Oil Co., E. J. Bischoffberger, Gen. Mgr., Freedom, Pa., awarded contract for the construction of a 3 story, 78 x 241 ft. mill building on Third Ave. to R. B. McDanel Co., 4th Ave. and 7th St., New Brighton.

Refinery — Coastal Petroleum Co., Mobile, Ala., plans the construction of a petroleum refinery. Estimated cost $200,000. Engineer not announced. Owner taking preliminary estimates on refining equipment, etc.

Refinery—Phillips Petroleum Co., Bartlesville, Okla., plans to rebuild refinery at Borger, Tex. destroyed by fire. Estimated cost $75,000.

Refinery (Oil)—Alleghany Refining Co., c/o W. E. Sawyer, Bolivar, N. Y., postponed construction of oil refinery, 1,000 bbl. capacity. Estimated cost $100,000. Maturity November or later.

Refinery (Oil)—Bowling Green Refineries Co., Bowling Green, Ky., awarded contract for stills, etc., for oil refinery to Leader Iron Works, Decatur, Ill. Estimated cost $100,000. Foundations completed.

Refinery (Oil)—Concho Refinery Co., H. J. Earls, Box 745, San Angelo, Tex., will build an oil refinery 500 bbl. capacity at Pioneer. Estimated cost $50,000. Work will be done by owners' forces. Wants quotation on complete laboratory equipment.

Refinery (Oil)—Houston Oil Co., Petroleum Bldg., Houston, Tex., postponed indefinitely construction of oil refinery at Viola. Estimated $250,000. Project may mature later.

Refinery Improvements — Phoenix Refining Co., Beeville, Tex., plans improvements to refinery including new stills and tower to increase capacity at Pettus. Estimated cost $70,000. Private plans. Work will be done by day labor under the supervision of owner.

Rubber Factory — Panco Rubber Co., M. Birstein, 31 Highland Ave., Chelsea, Mass., is having plans prepared for a 2 story, 75 x 85 ft. storage building at Highland St. and Congress Ave. Estimated cost $40,000. S. Schein, 333 Washington St., Boston, is architect.

Corn Syrup Plant — Corn Products Refining Co., Mexico City, Mexico and 17 Battery Pl., New York, N. Y., plans addition to plant at Aguascalientes, Mexico. Estimated cost $200,000. Work will be done by a subsidiary construction company which will build by separate contracts and day labor. Maturity late fall.

Soap Factory—John T. Stanley Co., 646 West 30th St., New York, N. Y., awarded contract for alterations to factory including foundations to Quinn Contracting Co., 646 West 30th St., New York.

Tallow Plant—Schonwalter Tallow Co., Woodruff Lane, Elizabeth, N. J., plans reconstruction of plant destroyed by fire. Estimated cost $50,000. Maturity indefinite.

INDUSTRIAL NOTES

AMERICAN COMMERCIAL ALCOHOL CORPORATION has removed its general offices to 405 Lexington Ave., New York.

CAROLINA WOOD PRESERVING CO., Charleston, S. C., is now in charge of the wood preserving plant of J. S. Prettyman & Son.

WORTHINGTON PUMP & MACHINERY CORP., Harrison, N. J., has acquired the manufacturing and marketing facilities of Metalweld, Inc., Philadelphia, Pa.

READING IRON COMPANY, Reading, Pa., has consolidated its general executive and sales offices at 401 North Broad St., Philadelphia.

LUKENWELD, INC., division of Lukens Steel Company, Coatesville, Pa., has appointed John F. Bleecker as manager of sales.

G. J. TAGLIABUE MFG. CO., Brooklyn, N. Y., has appointed A. F. Rucks as general sales manager.

EASTON CAR & CONSTRUCTION CO., Easton, Pa., has bought the industrial division of the Lakewood Engineering Co. for manufacture of its conveying equipment.

PRESSED STEEL TANK CO., Milwaukee, has appointed K. W. Cole as manager at 208 So. La Salle St., Chicago.

NEWARK WIRE CLOTH CO., Newark, N. J., has appointed F. C. Ryan as sales manager.

AMERICAN MANGANESE STEEL CO., Chicago Heights, Ill., has appointed W. C. Bruton as district manager for the Pacific Northwest with offices at 411 Colman Bldg., Seattle, Wash.

LUDLOW VALVE MFG. CO., Troy, N. Y., is now operating in Canada as the Canadian Ludlow Valve Mfg. Co., Ltd., with offices at 930 Wellington St., Montreal, and factories at Three Rivers, St. Thomas and Fort William.

INTERNATIONAL-STACEY CORP., Columbus, Ohio, has transferred B. T. Ehrnman to Railway Exchange Building, St. Louis, as division manager.

FULLER-LEHIGH COMPANY, has removed its Boston office to 49 Federal Street.

FERROCRETE CEMENT CO., INC., has removed its New York offices to 370 Lexington Avenue.